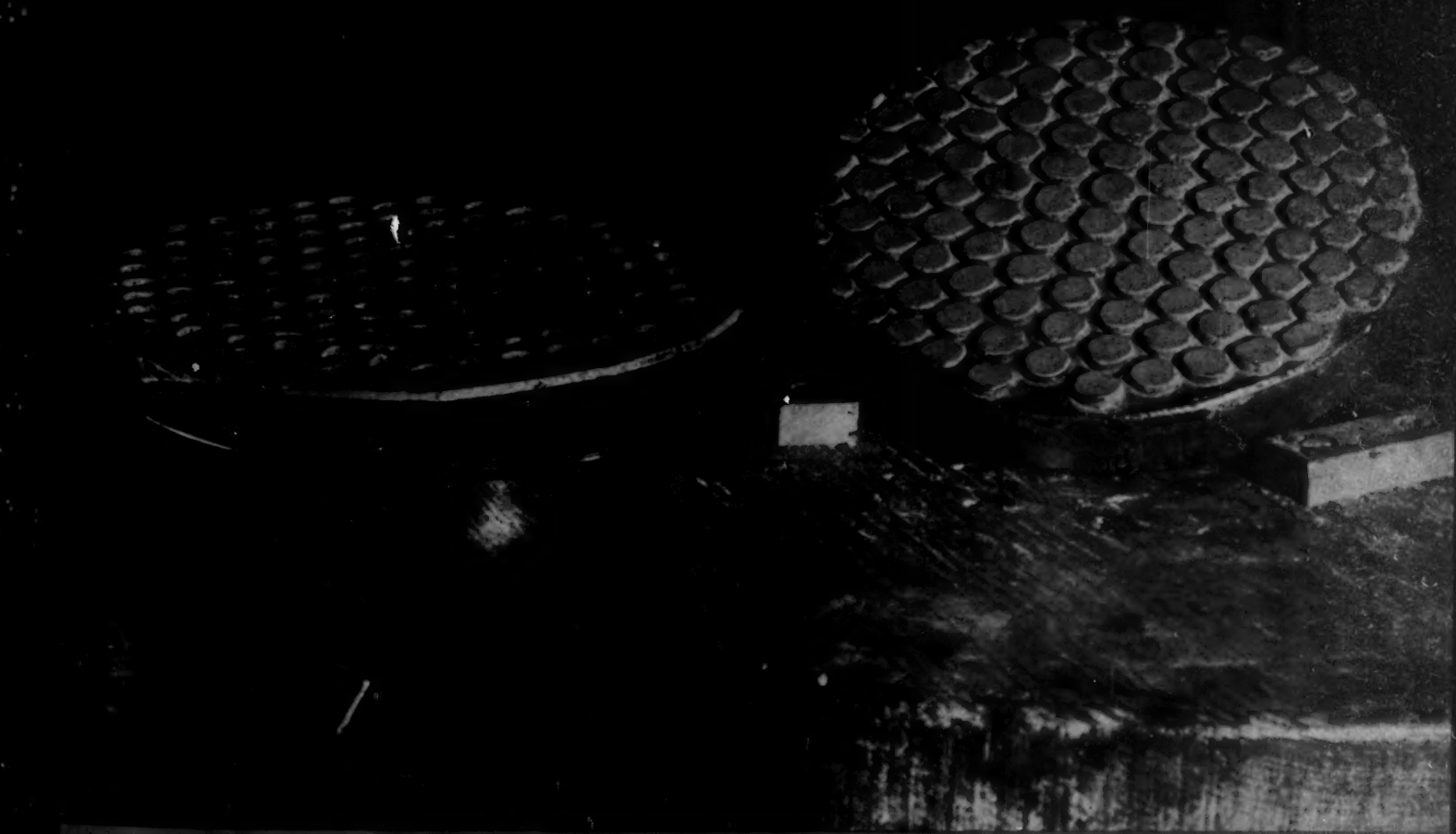
JUL 13 1944

Sky and TELESCOPE



Tools of the trade

★

Vol. III, No. 9

JULY, 1944

Whole Number 33

25 cents

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In This Issue:

The Asteroids

The Nature of Cosmic Rays—III

Summer Stars

Stars for July

In Focus

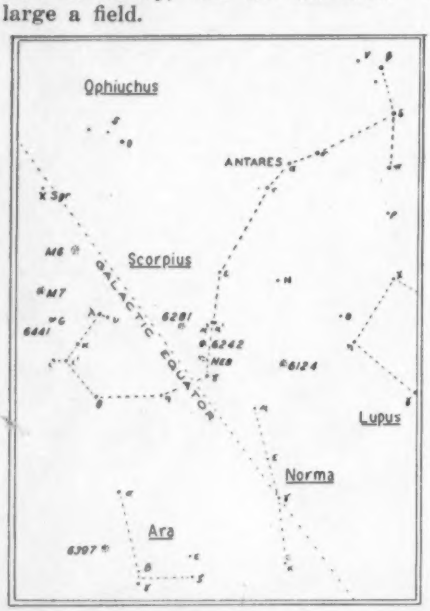
SCORPIUS stands brilliant above the southern horizon for northern observers this month. But to obtain satisfactory pictures of this entire region of the sky we look to the observatories of the Southern Hemisphere. At Bloemfontein, South Africa, where the back-cover photograph this month was taken with a 3-inch Ross-Tessar lens, the Scorpion passes through the zenith, permitting excellent photographs of long exposure.

The exposure in this case is three hours, bringing out the great star clouds and intricate structure of the Milky Way. The plate was sensitive chiefly to blue light, so many orange (spectral type K) and red (type M) stars appear relatively faint. Antares, the only 1st-magnitude star in the picture, appears much fainter than stars near it and in the Scorpion's head (extreme upper right of field). These stars, incidentally, have imperfect images because they are quite distant from the center of the plate.

Almost exactly in the center of the picture is the naked-eye double star, Mu Scorpii. Above it is Epsilon, a star of magnitude 2.36 but of spectral class K0 — hence, its relative faintness. The stars in the Scorpion's tail show up well, Lambda, magnitude 1.71, class B2, a blue star, appearing as the brightest object in the picture.

Alpha, in Ara, the Altar, is practically 50 degrees south of the celestial equator, so it barely appears on the horizon for observers at 40° north. Below it, compare Gamma Arae, magnitude 3.51, class B1, with Beta Arae, magnitude 2.80, class K2.

The two back-cover photographs, of the regions of Theta Ophiuchi (September, 1942) and of Antares and the head of the Scorpion (September, 1943), may be compared with this. All are of very nearly the same exposure, but, taken with a larger instrument, the two previous photos bring out more faint stars and nebulosity, but do not cover so large a field.



Sky and TELESCOPE

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The Editors Note .

ABOVE the front entrance to the Carlson Planetarium at Porter, Ind., is a wire scroll reading: "A Boy's Dream Coming True." The advent of summer reminds us that now is the time when children's eyes turn to the warm summer skies, and that acquaintance with the stars in youth brings happier outdoor hours throughout life. The Carlson Planetarium has no elaborate projector to bring the heavens indoors, but its mentor, Dr. E. H. Carlson, has achieved unusual results in presenting the facts of astronomy to children of all ages.

Elsa Strandberg Carlson, his wife, writes that visitors are welcome in any number, at any time of day or evening; it is desired that they remain for at least a one-hour lecture, star talk, or demonstration. "These may deal with any phase of astronomy, according to the mentality and education of the group or the individual, but never with astrology or any other non-scientific subject."

The breadth of this invitation was proven to your editor one crisp January night this year, when he was deposited from a bus in the moonlit snow in front of the planetarium, situated on U. S. 20 about 12 miles east of Gary. After an hour inspecting the building and its many unique devices, models, charts, and gadgets, all designed by Dr. Carlson to assist his enthusiastic audiences in understanding the stars, the hunger problem was even solved by Mrs. Carlson amid glowing accounts of trips west by the Carlsons and visits to large observatories and treasured photographs of famous astronomers.

Most impressive, perhaps because applying to those back home, was Dr. Carlson's demonstration of how he taught constellations to very little children. He reached into an old suitcase (its age no child would ever notice) and began pulling out things. They were very common things, mostly found in any dime store, but each was a constellation in the sky. There was a cup, a dipper, a big dog, a little dog, a rabbit, a king, a queen, and a host of others. I was a wondering child again myself as I learned what things really peopled the heavens. My amazement reached its climax when a small box appeared and in it were two tiny dolls. I had seen them before, many times—and so have you, but have you ever thought of them as the Twins?

Maybe it's just the grownups who make astronomy seem difficult.

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Whole Number 33

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FRONT COVER: Some tools of the amateur telescope maker's trade. The 6-inch mirror at left has been ground to curve and is ready for polishing and figuring. On it is the rubber mat which serves as a mold for making the pitch lap. At right is the tool with the completed lap attached. Photo by Peter A. Leavens. (See page 18.)

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BACK COVER: Scorpius and the Milky Way, photographed at Harvard's Bloemfontein station with a Ross-Tessar 3-inch camera, exposure 3 hours. (See "In Focus" on this page for details.)

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Historical

By W. P. Hirst

Astronomical Society of South Africa

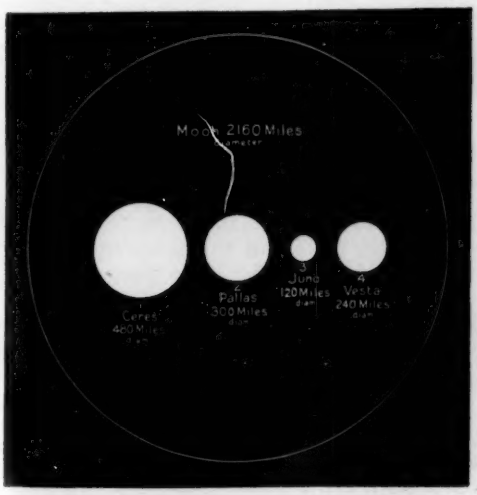
During the exposure required to photograph faint stars, if any minor planets are in the field, their motion causes them to appear as short streaks, as in two cases above.

THE ASTEROIDS

Last year the Monthly Notices *of the Astronomical Society of South Africa carried a series of articles on the minor planets. By courtesy of the society and the authors, the first two articles are republished this month, and further articles in the series will appear in subsequent issues.*

THE HISTORY of the asteroids starts before they were discovered. Their existence was first suspected as a result of the discovery of Bode's law as it was called: a relation between the mean distances of the planets from the sun. If we take the series of numbers, 0, 3, 6, 12, 24, 48, 96, and add 4 to each we get 4, 7, 10, 16, 28, 52, 100, which, if the earth's mean distance is taken as 10, represent the mean distances of the planets to a very fair degree of approximation except for 28, which is midway between Mars and Jupiter. It will be noticed that the series stops at Saturn which was the furthest known planet at the time the "law" was discovered. The subsequent discovery of Uranus, at a mean distance of very nearly 196, merely strengthened the belief in the significance of the "law" and stimulated interest in a search for the missing planet at distance 28. It must be mentioned that no theoretical reason for the rule has been found and the discovery of Neptune at distance about 300, whereas the rule requires 386, and of Pluto only half as far out as the rule demands, makes it probable that it is nothing more than a somewhat remarkable coincidence.

As so often happens, the "missing planet" was finally found by an observer who was not looking for it, but going about his lawful occasions without thought of new planets or similar diversions. Piazzi, of Palermo, was making a star catalogue. One night he noticed that one of his "stars" had moved. Thinking merely that here was a new comet, he observed it for a few days and noted its positions. As time went on, he became convinced from its appearance that it could not be a comet and he grew sufficiently interested to communicate his discovery to other astronomers. A little while afterwards he fell ill and before anyone else could pick up the object it had got too close to the sun.



The first four asteroids discovered are here compared in size with the moon.

Piazzi had only been able to observe the body for about six weeks and by the then existing methods of orbit computation the material was not sufficient to allow an orbit to be worked out. It so happened, however, that Gauss, a young German mathematician (whose name, ironically enough, is now associated with the measures taken to protect ships from magnetic mines laid by his compatriots) had just elaborated a method by which an orbit could be computed from only three observations. Here was a fine opportunity of trying out the new method, and Gauss computed an orbit of such accuracy that the planet was picked up again nearly a year later less than half a degree from the predicted position.

The new planet was named Ceres after the Greek goddess of the soil, who was traditionally associated with the island of Sicily. Within the next few years three others, named Pallas, Juno, and Vesta, were found, the first by Olbers, who was searching for Ceres at the time. Since 1846 no year has passed without at least one new asteroid being discovered and the total now numbers nearly 4,000, of which about 1,800 have had orbits computed.

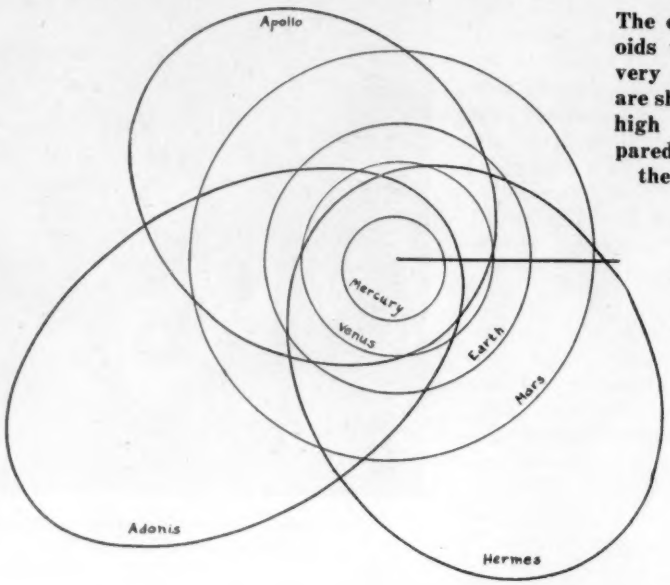
Towards the end of the 19th century a new departure was made by Wolf, of Heidelberg, who first used photography in searching for minor planets. His method was to photograph parts of the sky in the neighborhood of the ecliptic, where asteroids are most likely to be found, guiding the telescope on the stars which thus appeared on the plates as points. The asteroids, which move relatively to the stars, appeared as short lines, or *trails* as they are called. Using this technique, Wolf found many hun-

dreds of new minor planets, and he still holds the record for asteroids observed well enough to have their orbits computed reliably.

Among later minor planet observers must be mentioned Reinmuth, who has even surpassed Wolf in the total number of discoveries, though he is still behind in orbits.

One of the best known and most interesting of all the minor planets is Eros, which was discovered by Witt. This was the first whose orbit was found to pass inside that of Mars; in fact, the orbit is such that at the closest it approaches to within 13 million miles of the earth, at the time of its discovery closer than any heavenly body other than the moon, except for an occasional comet. This makes it an ideal means of determining the solar parallax and it has been extensively used for this purpose. A further point of interest is that the light from Eros has been found to vary at certain times. The variation is periodic with a period of $5^h\ 17^m$, but in this period there are two maxima and two minima. At other times no variation can be detected. To explain this it was suggested that the planet is rotating in this period and that it is of irregular shape, something like a rough brick. The rotation is supposed to be performed about one of the shorter diameters so that when we see it at right angles to the axis of rotation we observe it alternately end on and broadside on. As there are two sides and two ends presented to us in each revolution there are two maxima and two minima of brightness, as is actually observed. When the relative positions of Eros and the earth are such that we see it along the axis of rotation, it is seen broadside on all the time and there is no variation. This theory was brilliantly verified at the last favorable opposition when the planet was 16 million miles away. Dr. van den Bos and Mr. Finsen at the Union Observatory, who are two of the world's foremost double star observers and are thus accustomed to detecting very slight elongation of the stellar images in the telescope, were able to discern the shape of the asteroid and watched it rotate in the same direction as the earth does, in a period the same as its period of light variation. Dr. van den Bos described the appearance as similar to that of a double star of separation 0".18, which must have been extremely difficult to distinguish even in the 26½-inch telescope at the Union Observatory.

Finally, mention must be made of the extraordinary object known at the time as the Reinmuth object and afterwards named Hermes. This body, which is estimated to be no more than two or three miles in diameter, was photographed by Reinmuth when only about 700,000 miles from the earth, less than three times the distance of the moon. It was moving so fast that on the news of the discovery being telegraphed to other observers not one of them managed to find it. At its nearest it was moving at the rate of five degrees per *hour* and it passed across the sky in only nine days. One or two closely approaching asteroids had previously been discovered, notably Adonis and Apollo, but so far Hermes holds the record for closeness of approach.



The orbits of three asteroids which may approach very close to the earth are shown here. Note their high eccentricity compared with the orbits of the principal planets.

The Observation of the Minor Planets

By H. E. Wood

Union Astronomer, Johannesburg, Retired

DURING the last 33 years a considerable amount of work on the observation of minor planets has been carried out at the Union Observatory in Johannesburg. This was the result of the gift to the observatory in 1909 of the Franklin-Adams star camera with its powerful photographic triplet lens of 10-inch diameter and 44.6-inch focal length, an aperture of f/4.5.

A condition of the gift was that a number of the southern plates for the Franklin-Adams star chart of the sky should be repeated, as some of the plates of this series taken earlier at the Cape were not up to the high standard required. The completion of these plates was naturally the first work undertaken with the telescope when it was erected at Johannesburg. These plates were 15 by 15 inches in size, cut from specially selected glass and were given an exposure of two hours so that images of stars to about the 16th magnitude could be obtained. Before any negative was passed, it was carefully examined to see that the guiding had been good, that the star images were as round as possible, and that the limiting star magnitude had been reached. When the region photographed was near the zodiacal belt, occasional short trailed images were noticed on the plates. These were the images of minor planets which, of course, had moved a little during the two hours of the exposure.

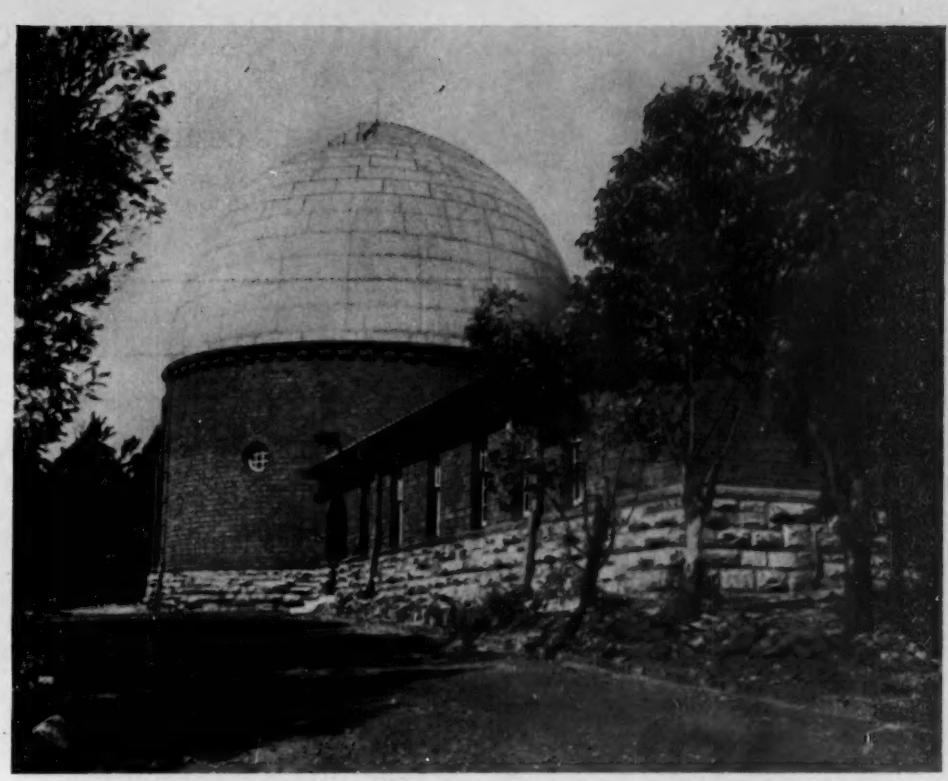
It was then recognized that the Franklin-Adams star camera was an ideal instrument for the discovery and observation of minor planets. The lens had a very large field, so that a considerable area of the sky could be photographed at a time; it also had a very powerful light grasp so that the trails of quite faint asteroids were visible. So, when the Franklin-Adams chart plates were finished, plates were exposed along the zodiacal belt for the observation of minor planets. After exposure in the telescope, a reseau was printed on the plate so that the negative was divided up into small squares. Each square was then scrutinized with a magnifying lens to detect among the many round images of stars the short trail of a minor planet. When such trails were found, the position of the planet was roughly measured in right ascension and declination and then reference was made to the ephemerides of minor planets prepared by the Astronomisches Rech-

en-Institut in Berlin. If the position agreed fairly well with the ephemeris position of a known asteroid and if the magnitude also agreed, then the identification was accepted, subject to confirmation to be supplied by a later photograph. Frequently it was found that the trail on the plate could not be so identified with any known minor planet and then it was marked as a possible new planet.

In 1911 a number of unidentified asteroids were photographed, and of these 715 Transvalia and 758 Mancunia were sufficiently well observed for their orbits to be determined and for the planets to receive names.

There are two photographic methods of observing minor planets. First, the straightforward method of guiding the telescope on a star so that the star images are round and the planetary images are trailed. The one obvious drawback of this method is that the very faint minor planets are lost because their light is spread out along the trail. Long exposure does not help here to strengthen the image of faint planets: it simply makes the trails longer. The second method is to guide the telescope to follow an imaginary minor planet. Then on the photograph the star images would all be short trails but the minor planets would have round, or nearly round, images. This method has the advantage of increasing the chance of photographing very faint planets but there are many disadvantages, chief amongst which is the fact that the photograph with trailed star images loses its value for other purposes.

The introduction of the Pulfrich stereocomparator or blink microscope revolutionized the procedure for observing asteroids. The long exposure necessary to obtain a recognizable trail was no longer needed and the tedious process of examining the whole plate for trails was eliminated. Now *two* photographs, of 30 minutes' exposure each, were taken of each region of the sky; the plates were exposed on the same evening, frequently without any interval at all between them, the second plate being exposed immediately after the first was finished. The two negatives were then placed in the stereocomparator. By operating a shutter the observer would see the same small area of each plate in rapidly alternating succession. If the two negatives were exactly comparable as regards the shape and density of the star images, the observer would not be conscious of any change when the shutter was operated. If, however, a minor planet came within the field of view, he would see its image jumping to and fro as the shutter was moved. Because of the



The dome of the 26½-inch refractor of the Union Observatory at Johannesburg, South Africa.

difference between the times of exposure of the two plates, the image of a minor planet would occupy a slightly different position on the two negatives. Then when the shutter was moved, all the star images would remain stationary but the planetary image would jump about. The whole plate would be examined strip by strip and the images of any minor planets found on it would be marked. Actually the examination of a pair of plates in the stereocomparator was very much less tiring and much more thorough than the examination of a single plate would be, because with the instrument everything that was common to the two plates was unnoticed by the eye and only the points of difference drew attention to themselves. Thus the stereocomparator was equally efficient in picking out variable stars. If the brightness of any star had varied between the taking of the two plates being compared, then the eye would be caught by the swelling and shrinking of its image as seen in the stereocomparator.

When the pairs of plates had been examined and the minor planets found on them had been marked, the work had only just been begun. The right ascension and declination of each planetary image had to be measured as accurately as possible. With the help of the *Astrographic Catalogue* the star images nearest to the planetary images were identified so that they could be used as reference points for measurement. There are various methods of obtaining the position of an object on a photograph, using neighboring star images as points of reference. Some of these methods are rather long. Ultimately it was found that by selecting a triangle of three reference stars round the image of a minor planet and applying the method of dependences introduced by Schlesinger, the position of the planet could be obtained with a sufficiency of accuracy and a minimum of labor.

Accurate identification of a known asteroid could generally be obtained from two photographs on which its image was found, by comparing its magnitude, its position in the sky, and its direction and rate of motion, with the ephemerides. When a planet could not be identified, then it was necessary to follow it up and to secure, if possible, five observations spaced fairly well over a minimum period of 40 days. This was to secure the necessary material for the computation of a preliminary orbit of the planet. This was never an easy matter and frequently it was not possible to obtain full information for every new planet found. If the necessary observations were secured, then the orbit computation for the new discovery was undertaken.

The computation of a general orbit by the classical methods is a lengthy process. When minor planets were being discovered at a rapid rate, it was realized that shorter methods of orbit computation were required and

considerable attention was paid to this problem. Of the new methods published, the one due to G. Merton was found to be very convenient and was adopted at the Union Observatory.

From the observations obtained of a new minor planet, three observations, generally the first and last and the one nearest the middle, were used in the orbit computation. The ideal was to secure three observations at equally spaced intervals, but breaks in the series of photographs due to the presence of the moon in the sky generally prevented this. After the orbit had been computed, an ephemeris was calculated for the period covered by all the observations. If there was a good agreement between the ephemeris and the three observations used in the orbit computation, the inference was that the orbit was free from errors of calculation. The orbit could not be accepted, however, unless there was also good agreement between the ephemeris and two other observations which had not been used for computing the orbit.

Very few other observatories in the Southern Hemisphere have participated in this work and from 1911 to the present time most of the observations of minor planets south of the equator have been obtained at the Union Observatory. Many new planets have been discovered there and the list of names of the minor planets will be noticed to contain many associated with South Africa. The name of the donor of the telescope used in this work is commemorated in the Asteroid 924 Franklina.

TIMES OF THE JANUARY ECLIPSE

A letter dated May 21st received at Harvard College Observatory from Dr. Joaquin Gallo, director of Tacubaya Observatory and leader of the recent Mexican eclipse expedition, relates to the times of totality of the January 25th eclipse, as reported in the May issue of *Sky and Telescope*, page 9. Dr. Gallo writes: "I must confess that my first computation of the duration of totality was wrong, and after recomputing, I found I had made a mistake and that the Peruvian astronomers were right. I should like to ask that *Sky and Telescope* publish a short note on this."

Thus, part of the discordance of times of the January eclipse is removed, but there still remains the fact that the observed times of contacts did not agree with those computed by the Lima astronomers. Ed.

NEWS NOTES

By Dorrit Hoffleit

NEW COMETS

Two comets have been recently discovered by astronomers in South Africa, the first, Comet du Toit, on May 16th by a member of the Harvard Observatory staff at Bloemfontein; the second, by Dr. H. van Gent, of the Union Observatory at Johannesburg, on May 23rd.

The comet found by H. du Toit will probably remain in the southern hemisphere of the sky, although a complete ephemeris has not yet been computed. On May 25th it was reported to be at $21^h\ 01^m$, $-63°\ 44'$, and of magnitude about 10. Elements computed by Dr. F. J. Bobone, of Argentina, indicate that the comet reached perihelion on June 10th, and it had already passed the position nearest the earth, so an increase in brightness is not to be expected.

The position of Comet van Gent at discovery, as reported from Union Observatory, was $9^h\ 24^m.8$ and $-49°\ 20'$. A diffuse object of 12th magnitude at discovery, the comet may or may not increase in brightness. Its daily motion at that time, of $2^m\ 36^s$ east and $42'$ north, may be carrying it sufficiently far north to be observed in the Northern Hemisphere.

Added in press: Dr. John Jackson, of the Cape Observatory, has cabled the orbital elements and an ephemeris of Comet van Gent. It is traveling northward through Hydra, Leo, and possibly Ursa Major, but is not expected to increase much in brightness. Perihelion passage is on July 18th, at 2.2 atronomical units from the sun. Predicted positions were June 11, $10^h\ 4^m.7$, $-36°\ 59'$; June 15, $10^h\ 18^m.5$, $-34°\ 28'$; June 19, $10^h\ 26^m.9$, $-32°\ 04'$; all for 0^h Universal Time.

CORRECTION

In our news note on "New Unseen Companions" last month, an error inadvertently crept in. The semimajor axes quoted as 0.118 and 0.132 astronomical units for Barnard's star and Lalande 21185, respectively, do not refer to the *relative* orbits as stated, but to the orbit of the *center of light* about the center of mass (the photocentric orbit).

When the two images of a double star are blended into a single image, the center of light does not coincide either with the center of gravity of the system or with the center of light of the brighter component. In terms of the distance between the two component stars as unity, the center of light is at a distance from the center of mass represented by the difference: the ratio of the mass of the companion star to the total mass of the system minus the fractional luminosity of the companion in terms of the combined luminosity of the system. On the assumption of a total mass of 0.4 suns in each of the two systems, this difference is found to be 0.15, which leads to values of 0.8 and 0.9 A.U., respectively, for the true semimajor axes of the relative orbits of Barnard's star and Lalande 21185.

We are indebted to Dr. Peter van de Kamp for pointing out this error.

NEW CELESTIAL NAVIGATION INSTRUMENT PROPOSED

At the meeting of the American Geophysical Union recently, Dr. T. A. Jaggar, of the University of Hawaii, proposed a device which may assist in celestial navigation from airplanes. He suggests that a mirror be used to reflect images of the real stars onto the stars on a printed sky map. The navigator is to observe this map through a lens, and make reference to a special graphic chart and his watch, to obtain his latitude and longitude. There appears to be the ever-present problem of maintaining a satisfactory horizon if the position is to have sufficient accuracy to replace present methods requiring bubble sextant observations of the stars.

COMET TAILS MAKE THE WEATHER?

Although it was not his main theme, Dr. H. B. Maris, of the U. S. Naval Research Laboratory, suggested to the American Geophysical Union that one seventh of all fluctuations in the earth's magnetic field are due to gases from the tails of comets, swept up out of space by the earth as it swings across the numerous cometary orbits which intersect its path. The relation of these orbital magnetic disturbances to weather, he said, should be quite different from that of the more common magnetic fluctuations caused by ultraviolet radiation from the sun.

Dr. Maris' principal suggestion was that instead of going directly to the sun, sunspots, or solar radiation for measures which might be correlated with weather changes, a century's accumulated records of changes in the earth's magnetic field be used. These show many persistent cyclic variations which represent world-wide changes useful in making long-range weather forecasts.

ASTRONOMICAL ANECDOTES

OCCULTATIONS, TELEGRAPH, AND BIG TELESCOPE

ON Sunday, April 30th of this year, I observed the daylight occultation of Jupiter by the moon. The timing of the first and third contacts was very difficult but, for what they are worth, here are the times as I clocked them: 1st at 3:48:00, 2nd at 3:49:13, 3rd at 5:02:11, 4th at 5:03:12. All times are p.m., E.W.T. Because of the difference between the intervals 1st to 2nd and 3rd to 4th, I am very sure there are bad errors.

At an occultation of Jupiter on May 23, 1860, G. P. Bond reported that at immersion the time required for the disappearance was $1^m\,07^s.71$; at emersion, the time required was $1^m\,06^s.72$. After observing 40 occultations, perhaps I could trust my 41st observation to the nearest second; but even to contemplate timing an occultation of Jupiter to a hundredth of a second . . . !

A much more interesting thing occurred shortly before 10 p.m., Cincinnati time, on March 28, 1860, when G. W. Hough "witnessed an expected emersion from the limb of Jupiter of a 9½th-magnitude star. When first seen, it was distant from Jupiter's limb about one diameter of the first satellite (or 1″ of arc); so that the real separation had taken place about 6 minutes before . . . . At $10^h\,27^m$ sidereal time, the star was occulted by the *first* satellite, and remained invisible 8 minutes."

After a great deal of figuring, I calculated that at the time of the event described the first satellite was 45″.5 west and 2″.2 north of the center of the disk of Jupiter, and approaching the limb of the planet. At that moment, the satellite's motion across our line of sight, referred to the center of Jupiter, was at the rate of 9.85 miles per second; the motion of Jupiter across our line of sight at the moment was at the rate of 7.96 miles per second. These motions combine to give 17.81 miles per second for the motion of the satellite across our line of sight. The occultation required eight minutes or 480 seconds, during which time the satellite moved a distance of 8,550 miles, or 3.7 times the accepted diameter of the satellite. Yet it should be a way of determining the diameter of the satellite. What could be wrong?

Like determining longitude from observations of Jupiter's satellites, this computation is better in theory than in practice. For when the result came out wrong by almost three whole diameters of the satellite, I suddenly recalled that it had been "a 9½th-magnitude star" and it "remained invisible" for eight minutes. Certainly it would, for the star was approximately 1/60 as bright as the satellite, and would be lost in the glare long before the actual body of the satellite covered it up! I had computed, then, the irradiation diameter of the satellite and not its real one. I did it fairly fast, too, and there may be an error in it; anyone who would like to check the value I obtained, or obtain another, is welcome to it.

The report of Prof. Hough I found in No. 17 of the journal, *Astronomical Notices,* founded at Ann Arbor by Francis Brünnow in 1858, and published for only 29 numbers, the last one being dated March 18, 1862. For about a year while director at Ann Arbor, Brünnow was also director of the Dudley Observatory at Albany, and in No. 20 of *Astronomical Notices,* dated June 30, 1860, he told how he and G. P. Bond at Harvard determined the difference in longitude between Albany and Cambridge. They used a chronograph at each end of the telegraph circuit, and each man held a key which actuated both chronographs. Brünnow said, "The same stars were observed both here and at Cambridge, and each ought to have been recorded on both chronographs; but *owing to a very splendid aurora, the current was much disturbed, and a great many signals were lost . . . .*" It might be added here that there was a maximum of sunspots in August, 1860, only a couple of months after these observations were made. (Italics are mine.)

This early reference to recognition of a connection between auroral displays and telegraphic disturbances causes me to wonder just how early such a connection was suspected. After all, it was not until 1844 that the first commercial telegraph line was opened, between Baltimore and Washington.

I do so much doubting that sometimes when I feel a good one coming on I resolve not to let it take hold. More often than not, I should have let it take its course. For example, when I read of the 120-inch reflector at the new Astrophysical Station at Saint-Michel, Haute-Provence, I wanted to wait until I could lay hands on a copy of the January, 1942, issue of *Annales d'Astrophysique* before considering it settled. The only copy I knew how to look for was unavailable at the time, so I let it go through, although I suspected this mirror to be the 120-cm. (48-inch) stored for so long at the Paris Observatory, and not a new 120-inch. Now my suspicion has been confirmed, for in a letter from Dr. Struve, editor of the *Astrophysical Journal,* the correction is announced. And, to clinch the matter, I have at last been able to read the original account in *Annales d'Astrophysique.* The 100-inch Hooker reflector at Mount Wilson remains the largest telescope in operation.

And, to close another item, appearing in this department in The SKY, November, 1940, I quote an AP dispatch to the effect that Sir Arthur Quiller-Couch died May 12, 1944, at the age of 80, in Fowey, Cornwall. He wrote many fine romances and later established a reputation as a salty critic and lecturer on literature. He was widely known to his readers as "Q," and some of you may like to run down the issue in which I quoted from his *Ia.* The AP story tells us that "the author had been in declining health since March, when he was knocked down by a jeep." "Q" is dead, but Ia's little boat speeds ever westward. R.K.M.

CELESTIAL ELECTRONICS

The moon seems to have something to do with radio reception—more perhaps than might have been expected. This results from some 18,000 hours of field-intensity measurements of radio transmission and reception between Boston and Chicago, made within eight years by the Laboratory for Cosmic-Terrestrial Research at Needham, Mass. The work of this laboratory is summarized in the March *Scientific Monthly* by Dr. Harlan T. Stetson, who writes:

"Contrary to all expectations, our records showed a definite improvement in radio reception from new moon until about two days before full moon."

In interpreting the phenomena, a new field, *celestial electronics,* appears to have been introduced. The moon, which has essentially no atmosphere, is being bombarded by ultraviolet radiation and high-energy particles emitted by the sun. As a result, the lunar surface emits electrons and secondary X-rays, some of which reach the earth, ionizing the upper atmosphere; the degree of ionization of the upper atmosphere is highly important in radio transmission and reception. Sunspot eruptions seem to enhance the lunar factor in addition to their better-established direct effects.

The results of the investigation and the suggested interpretations are still provisional; Dr. Stetson emphasizes that they are published at this time to stimulate independent investigations by others.

THE NATURE OF COSMIC RAYS

By W. F. G. Swann

Director, Bartol Research Foundation of The Franklin Institute

The Bartol Research Foundation has a tower at its side, the lower section of which constitutes a room and the remainder is filled with water. In this tower one of the measurements of the life of a mesotron was made by T. H. Johnson and M. A. Pomerantz.

A SUMMARY OF THE FIRST AND SECOND INSTALLMENTS

THE COSMIC atomic particles continually disrupt (ionize) the atoms of the atmosphere, rendering the air capable of conducting electricity. Cosmic radiation increases in intensity with altitude above the earth's surface and possesses power to penetrate into deep mines and to the bottoms of lakes.

The study of cosmic rays is closely linked with the fundamental building blocks of physics, which for a time were thought to be three in number: the negative electron; the proton, 2,000 times heavier than the electron but of equal positive charge; and the photon, a kind of ghost particle representing light and other forms of electromagnetic radiation. More recently, however, studies of atomic phenomena have revealed more particles, the most important of which for cosmic rays is the mesotron, a particle 200 times heavier than the electron and possessing a charge of either sign.

A high-energy particle, in passing through matter, expends energy by ionizing (ejecting electrons from) the atoms it passes. We now know that occasionally a high-energy electron may lose all or a large part of its energy in creating a photon at a suitable atomic encounter. Photons were formerly believed to confine their activities to the occasional emission of high-energy electrons from atoms. Now, however, we know that a photon of high energy possesses the power, on suitably encountering an atom, to materialize into a positive and negative electron. Mesotrons are characterized by having but a finite life. For a very slow-moving mesotron, the average life expectancy is about two millionths of a second. Mesotrons of high velocity may live longer. Ionizing the air is a mesotron's only activity.

Originally cosmic rays were thought to be high-energy photons—very short X-rays. Electrically charged particles seemed ruled out because of the energy, then considered enormous, which they would have to possess to pass right through the atmosphere and even to reach the atmosphere through the earth's magnetic field, which tends to turn them back into space. However, the discovery of the latitude effect in cosmic rays made charged particles a necessity for its explanation. The energy necessary for a charged particle to penetrate the earth's magnetic field gets less as the magnetic latitude increases. Thus more and more of the low-energy incoming rays reach the atmosphere as we travel to increasing latitudes.

However, an electron with energy sufficient to penetrate the magnetic field at the equator would have no difficulty in traversing the atmosphere, so that we should expect no diminution of intensity with altitude at the equator. This conclusion, contrary to the facts, led the author to propose that the primary rays produced secondary particles in number proportional to the primary energy, so that the number of electrons observable at high altitudes would be expected to be greater than the number at low altitudes on account of the greater primary energy at high altitudes. A maximum in the intensity would be expected at a certain altitude because, if we ascend sufficiently far, there will obviously be insufficient atmosphere above to provide many secondaries. This idea received its detailed exemplification in that process already cited in which high-energy electrons produce photons, which in turn give birth to additional electrons.

PART III

5. A new particle in cosmic radiation in the atmosphere

IT RESULTS from the rapidity of loss of energy by a primary high-energy electron in passing through matter that, unless we are willing to admit energies which seem out of the realm of reason, nearly all of the primary electrons entering the earth's atmosphere would be stopped before they had descended through more than a small fraction of that atmosphere. The situation is as though in the higher regions of the atmosphere there were a department of immigration which stopped all the incoming immigrants and permitted only the children born in the country and subsequent generations to descend to the favored regions below.

Moreover, even the children are not allowed to go far, for when we make calculations in terms of the known atomic quantities associated with the rays, we find it unreasonable to expect that an appreciable fraction of the progeny of the primary parent could get down as far as the earth through the atmosphere. But we observe cosmic rays at the surface of the earth, and we observe them in coal mines and in other considerable depths, and in measurable amount down to distances of more than 250 meters under water. What is it that gets down to these great depths? Low-energy electrons or photons could not travel as far as that because they have not enough energy, and high-energy electrons or photons could not travel that far because they commit suicide too rapidly and give ultimately low-energy progeny. The question thus arose—what other kinds of particles are there?

Whatever the nature of the particles primarily responsible for what is observed at sea level, we must suppose that the representatives of these particles carry electric charges when they enter the atmosphere; for how else could we invoke the earth's magnetic field for the purpose of explaining the latitude and allied effects? It was suggested that the radiation observed at sea level and below may consist of protons which there was reason to believe did not experience the multiplicative process characteristic of electrons. However, apart from all other troubles, there is a fundamental difficulty in assuming protons to be operative appreciably at sea level. For since the number of rays varies with altitude even in the vicinity of the

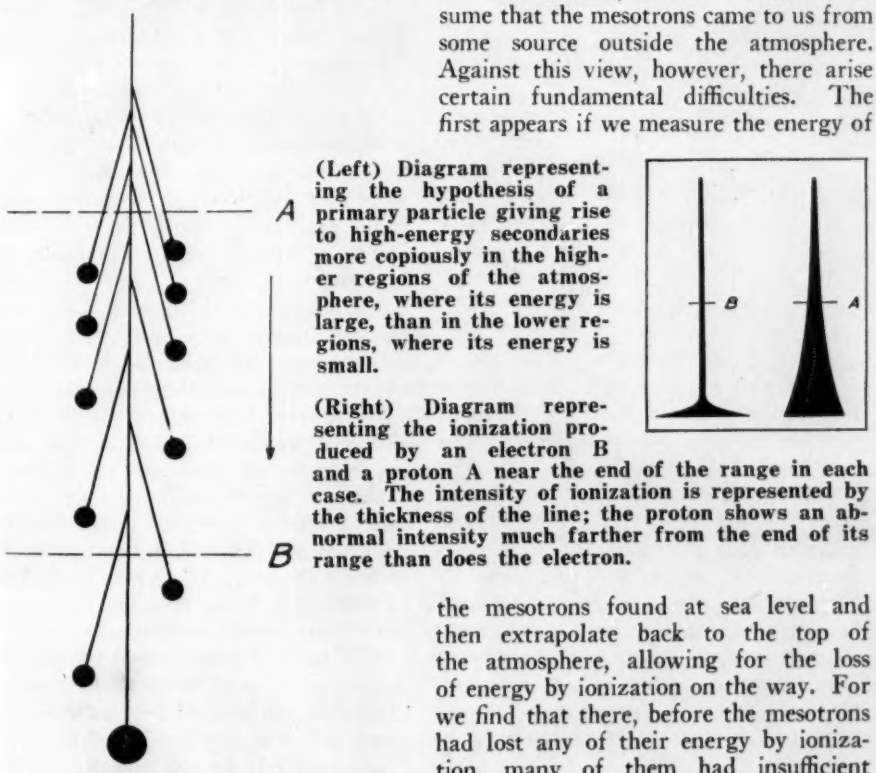
earth's surface, we are in a position to deduce just how many disappear in any assigned thickness. We can deduce, for example, how many would end their existence in some measuring vessel in which we sought to measure the spurts of conducting power contributed to the gas as each ray passed through it. Now I have already referred to that characteristic feature of a charged particle which causes it to expend its wealth — in the form of energy — more or less parsimoniously when it is rich, and then more and more lavishly as it sees bankruptcy approaching. There is no evidence that charged particles originated in Monte Carlo, but they seem in this matter to have the gambler's instinct. Now protons start this lavish expenditure farther from the point of bankruptcy than do electrons. For an electron, the period of lavish spending just before bankruptcy is so small that the remnants of the final party are hardly observable. However, the protons carry on in the hilarious mood for a time which is considerably longer, with the net result that the actual ending of the active life of a proton is something which would produce enough evidence to become measurable; yet no such evidence has been found.

Until comparatively recently, it was very difficult to correlate the various known facts in these connections with the properties of any of the particles which atomic physics had placed at our disposal. Charged particles heavier than the proton would only have presented the difficulty in more acute form. The neutral particle, the neutron, was of no use since it carried no electric charge and, therefore, could not make itself evident in the way that cosmic rays do. And then only a few years ago, it was found that the majority of cosmic rays observed at sea level had, in actuality, a mass about 200 times that of the electron and 1/10 that of the proton. These particles are the mesotrons of which I have spoken. Our theories teach us that with a mass as *large* as this the particle is relieved of the responsibility of having to become progenitor of a long line of offspring as must the high-energy electron. However, with a mass as *small* as this — a mass 10 times smaller than that of the proton — we are relieved of the embarrassment of having to predict that terrific increase of activity near the time of final retirement from active service necessary in the case of the proton.

The mesotron loses energy only by ionization, so it can penetrate to the great depths at which we find the cosmic rays. The mesotron is the most penetrating thing in all physics.

It flies through the air with the greatest of ease,
But unlike the Man on the Flying Trapeze,
It bumps against everything found on the way
Till at last we have naught but a dead cosmic ray.

At this stage, therefore, and without further evidence, it was natural to assume that the mesotrons came to us from some source outside the atmosphere. Against this view, however, there arise certain fundamental difficulties. The first appears if we measure the energy of the mesotrons found at sea level and then extrapolate back to the top of the atmosphere, allowing for the loss of energy by ionization on the way. For we find that there, before the mesotrons had lost any of their energy by ionization, many of them had insufficient energy to get into the atmosphere through the earth's magnetic field. It becomes necessary, therefore, to assume that some of the mesotrons, at any rate, are produced in the atmosphere itself and this, of course, incites us to assume that all of them are produced in the atmosphere if there should be any other circumstances which point to that conclusion.



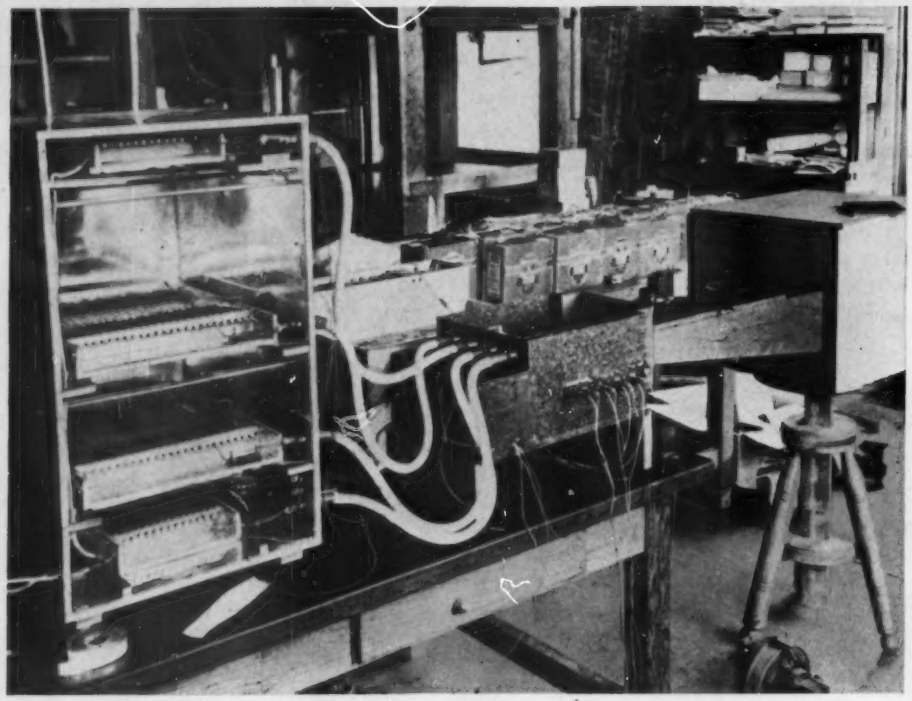
(Left) Diagram representing the hypothesis of a primary particle giving rise to high-energy secondaries more copiously in the higher regions of the atmosphere, where its energy is large, than in the lower regions, where its energy is small.

(Right) Diagram representing the ionization produced by an electron B and a proton A near the end of the range in each case. The intensity of ionization is represented by the thickness of the line; the proton shows an abnormal intensity much farther from the end of its range than does the electron.

Cloud chamber picture by R. P. Shutt, S. de Benedetti, and T. H. Johnson, showing the death of a mesotron. AB is the path of the mesotron; its life is terminated at B, and it gives rise to an electron BC.

A second piece of evidence favoring this view arises from the fact, which I have already cited, that these mesotrons have only a limited life. They do not all live to the same age but, like men, have a certain expectancy of life — a certain *mean life*, as we call it — at birth. Moreover, the mean life is greater for those groups which are born with high energy than for those born at rest.

If the mesotron could live forever, the theory of ionization, that is, of the disruption of atoms by rays passing near or through them, would lead us to expect that the fraction of the mesotrons absorbed in a certain thickness of water would be the same as the fraction absorbed in an equivalent thickness of air (equivalent in the sense that the masses per unit area are equal). This, at any rate, with slight modifications concerning which the theoretical physicists are perfectly happy, represents the current view. If, however, the mesotron has a finite life, then the disappearance in the water will be less than in the very much longer extent of air, since the time to penetrate the latter is so much greater than the time to penetrate the former. By comparing the absorption of mesotrons in air and water and seeing how much the ratio departs from what would be expected if the life of the mesotron were infinite, it has been possible to determine the average life of the mesotron. This comes out to be of the order of two one-millionths of a second for mesotrons of small energy; and although the life increases with the energy, a factor



Apparatus used by the Bartol Research Foundation in a deep mine to investigate the existence of electron showers. The apparatus comprises four trays of Geiger counters and operates according to principles like those described with the picture of cosmic-ray-shower apparatus on page 8 last month.

of a million in the life would only give the mesotron two seconds to live. Such a situation is completely antagonistic, therefore, to the view that the mesotrons come from outside of our atmosphere, for even if they came from a body as near as the sun and traveled with the velocity of light, they would take eight minutes to get here and practically all would have died before they arrived.

But there is still further evidence in favor of the assumption that the mesotrons are produced within our atmosphere. I have already referred to the fact that the earth's magnetic field deviates the paths of charged particles to an extent depending upon their direction of approach, also depending on the latitude and, I may add, for any given direction, upon the sign of the charge, positive or negative. It is easier for positively charged particles to come in from the west than from the east, and the converse is true for negatively charged particles. Studies of the relative east-west cosmic ray intensities have led to the conclusion that practically all of the charged particles which enter the atmosphere from outside and succeed, either directly or indirectly, in producing effects at sea level are of the positively charged type. However, when we examine the *mesotrons* to be found at sea level, we find from their deviations in magnetic fields that they are practically equally distributed as regards positive and negative sign of charge. This means that the mesotrons cannot themselves be the primary rays. They must have been brought into existence by some other primary which was itself positively charged, and which, therefore, entered the atmosphere in amounts varying with latitude and direction to the extent determined by the fact that it *was* positively charged. We must then suppose that this primary ray coming into the atmosphere in some way creates mesotrons which continue its journey of flight, but which can very well have been created in equal numbers, positive and negative.

Although it is very unlikely that an appreciable fraction of any *electron* rays entering our atmosphere — or of their progeny — could reach down to the earth, nevertheless, in deep mines we find electrons with cosmic ray energy in considerable numbers. The only particles which we have a right to expect as capable of *penetrating* to such depths are the mesotrons, so that these electrons must be the offspring of mesotrons and must have their origin in the substance of the earth not far from the places where they are found. We have already remarked that electrons are born from the death of mesotrons, and some of these electrons found in deep mines have their origin in this manner. But mesotrons do possess the power actually to knock electrons out of atoms occasionally, and without doubt some of the electrons found at great depths arise in this way.

To sum up, therefore, it was customary to believe, at any rate until quite recently, that two kinds of particles entered our atmosphere from above, electrons (positive and negative) and a heavier type of particle, probably a proton. It has been supposed that the electrons, on entry into the atmosphere, propagate their species according to the principles already enunciated, giving rise during this process to those ghosts, the photons, which come into evidence at each new generation. The belief has been that these successive generations of electrons and photons constitute the main part of the cosmic radiation in the upper regions of the atmosphere and that their activities are observable in appreciable amount down to altitudes of two or three miles from the earth's surface. On the other hand, the heavier particles, the protons, for example, have been supposed to be capable of producing mesotrons, by mechanisms not yet thoroughly understood; these mesotrons, as already stated, are particles about 200 times as heavy as the electron, capable of carrying either a positive or a negative charge. The vital characteristic of the mesotrons is their power to pass through considerable thicknesses of material, a power which they possess because, as our theories show and as experiments corroborate, they are too heavy to experience appreciable loss of energy by propagation of their species. Moreover, these mesotrons are too light to exhibit the reckless expenditure of energy at the ends of their paths which we should expect were they as heavy as protons.

6. The primary particles giving rise to mesotrons

LABORATORY measurements have taught us how much energy is lost by ionization when a mesotron passes through an assigned thickness of air, and it is possible to conclude that a mesotron, having energy such as would be given to it by a fall through 20 billion volts, could penetrate through the atmosphere and to a further depth comparable with 200 meters of water. There was a time when nobody would have had the courage to suggest such energies as would be associated with a billion volts, but today, in the cosmic ray field, 20 billion volts does not trouble anybody. It is rather interesting to note that the cosmic ray energies in volts are about comparable with national appropriations in dollars, a fact from which I wish to draw no scientific conclusions, except insofar as both situations show the adaptability of the human mind to accept large numbers when it has no alternative.

We have to picture the mesotrons as accompanied at all depths by companion electrons. These electrons have been produced — at the lower depths, at any rate — entirely by the processes of having been knocked out of atoms by mesotrons or by the deaths of mesotrons, and, of course, by the subsequent actions of these electrons in giving rise to progeny by the ordinary process of pair forma-

tion. Presently, I shall have to return to question the origin of electrons found in the higher regions of the atmosphere, but for the moment we will let the picture stand and inquire more in detail as to the nature of the heavy particle or particles which are the parents of the mesotron.

Having defined in a general way the characteristics which the incoming heavy particle must have, the proton stands as a very obvious candidate. However, it evidently would be very desirable, if possible, to show that those requirements

Photographic record of the data obtained with the apparatus pictured opposite. The thin lines which look like a spectrum show, on a moving film, the occasions when a mesotron passed through the apparatus. A peak in the record above or below the thin lines shows an electron shower whose magnitude, as measured by the number of rays, is proportional to the peak's height.

necessitate a heavy particle whose mass is just equal to that of the proton. With the idea of clinching the matter in this way[1], I have started with the working hypothesis that whatever the particle may be, on entering the atmosphere it breaks up in such a manner that the resulting mesotrons continue to travel along with the velocity which it possessed before the catastrophe. In other words, the assumption is that the heavy particle splits up so that its mass is divided between the mesotrons, and, consequently, the velocity of the mesotron is equal to that of the primary. It also follows that the distribution of kinetic energy among the mesotrons will be exactly the same as among the primary particles, except that corresponding energies in the case of the mesotrons will all be divided by N, where N is the number of mesotrons produced by a primary and, therefore, the ratio of the mass of the primary to that of the mesotron.

Now it is not to be expected that the mesotrons will all be produced at one altitude. However, let us assume, as seems quite customary in this field, that there is an effective altitude of production — a kind of center of gravity of production — and let us assume tentatively a distribution of energy among the mesotrons. Then it is possible to work out what is to be expected as regards the variation of mesotron intensity with altitude and with latitude, as well as to obtain the expected energy distribution at sea level. The assumptions as regards altitude of production and energy distribution can then be adjusted to harmonize with the facts, and what is most important, it is possible to determine the *lower limit of the kinetic energy* for the mesotrons at the altitude of production for the equator, and to determine the mesotron velocity corresponding to this energy. This velocity must be the same as that of the heavy particle for the reasons already stated.

We are thus in possession of the lower limit for the velocity of the heavy particle on entry into the atmosphere, since that particle would lose very little velocity in penetrating to the very high altitude of production. We can then ask what mass the heavy particle must have had in order that the said velocity is the lowest with which such a particle can enter through the magnetic field at the equator. The result comes out equal to the mass of the proton. The observations used in the above calculations are those at sea level and at altitudes not above four kilometers, so we can conclude that the mesotrons observed *at these altitudes* have come from primary particles which are *protons*. I must add that once the idea of a heavy particle came into evidence several investigators, including the writer, suggested protons as likely candidates for the position, but the object of the calculations above cited was to *determine* the mass of the primary particle and to show that the particle is, in actuality, a proton. This matter has some importance for, as will appear in our concluding installment next month, there is evidence that the proton is not the only primary particle which is not an electron.

[1]These ideas have been developed and extended considerably in a paper, "The Variation of Mesotron Intensity with Altitude and Latitude, Together with Allied Phenomena, and the Bearing of these Matters on the Nature of the Primary Particles" (*Jour.* Frank. Inst., *236*, 1, July, 1943, and *236*, 111, August, 1943), and still further in a paper as yet unpublished.

NEW ATOM SMASHERS

Atom-smashing projectiles bearing 15 million electron-volts energy are now being produced by the new cyclotron put into operation this spring at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. This is one of the two largest cyclotrons in operation in the world, the other being at Berkeley, Cal. It weighs 225 tons and took four years to build.

In the accelerating chamber of the cyclotron, about 60 inches in diameter, atomic particles receive a succession of electromagnetic impulses which cause them to whirl around in continually widening circles at tremendous speeds, until finally they reach a window on the side of the chamber where they bombard whatever element is placed there for study.

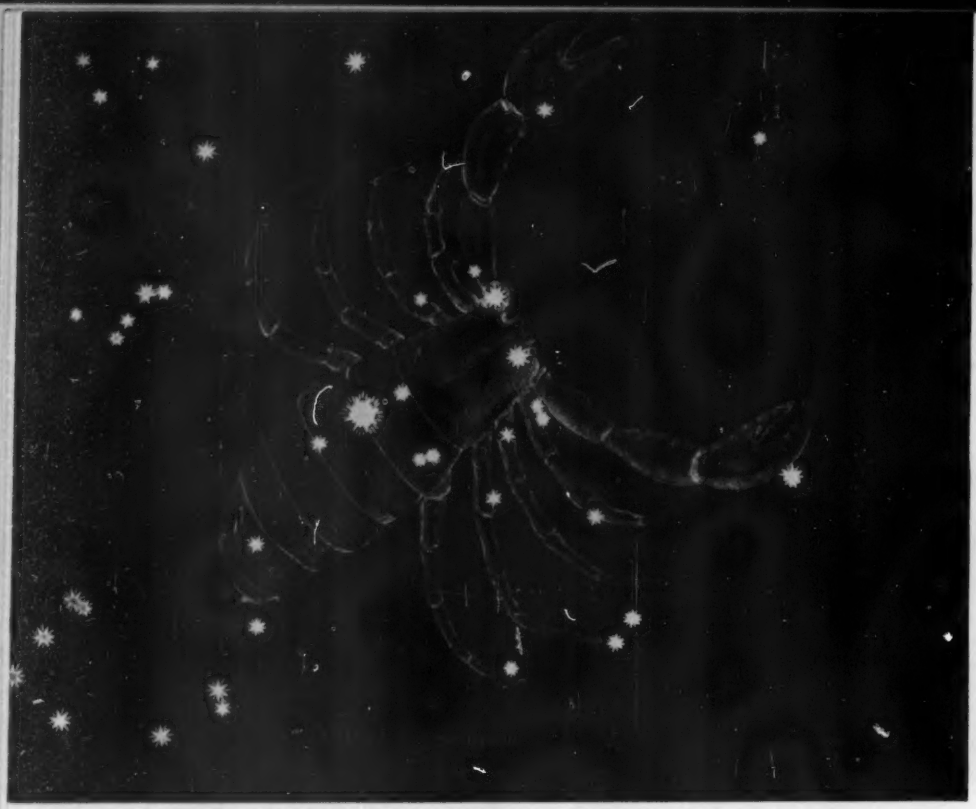
Science Service reports that the Carnegie cyclotron is housed 10 feet beneath the earth's surface to prevent the powerful radiations it produces from reaching people outside. Operators of the cyclotron, including Dean B. Cowie, physicist in charge, never see the cyclotron in operation; master switches on doors leading to the high-voltage parts of the laboratory automatically cut off all power when these doors are opened.

The cyclotron was the invention of Prof. E. O. Lawrence, of the University of California, who received a Nobel prize for its development. At the present time he is working on the most powerful cyclotron in the world, equal to more than three of the latest 60-inch instrument.

In another release, Science Service reports that the University of Illinois will build a 250-million-volt betatron after the war. This instrument will be similar to the 225-ton cyclotron in size, shape, and method of operation, but it has a changing instead of a constant magnetic field and whirls electrons (beta rays) instead of the deuterons used in a cyclotron.

At present, a 100-million-volt betatron is located at the General Electric Company laboratories in Schenectady. Two smaller machines have been in operation at the University of Illinois for several years. Speaking of these, Prof. G. M. Almy, of the university's department of physics, stated: "The first 2,500,000-volt betatron proved the idea workable. The 20-million-volt betatron in its two years of operation has made several valuable contributions to the knowledge of atoms, electrons, and X-rays."

It is expected that a 250-million-volt betatron can provide a laboratory source of mesotrons, the important particles discovered as constituents of cosmic rays.



Scorpius really resembles the object for which it is named, as this reproduction from Bayer's famous "Uranometria" shows. Antares is the brightest star, located in the Scorpion's heart.

SUMMER

By Marian L

More people become interested in the s other time of the year. Here and in the many interesting facts and legends once bors are discussed. See the back cove Scorpius and region to

THE SKIES of summer present to the amateur stargazer rich fields of stellar beauty. While the average observer regards Orion, which is a winter constellation, as the most beautiful of all star groups, there is at least one, the Scorpion, which gives the summer sky an equal claim to consideration.

After dark about the first of July, Scorpius is visible from the latitude of New York just over the southern horizon. It has been described as looking very much like a huge baling hook, but to the more imaginative eye, it resembles the figure for which it is named. Scorpius is believed to be one of the most ancient of the constellations, and for a long period of time before the Christian era it surpassed all other zodiacal constellations in size. At that period, however, the constellation included our modern constellation of Libra, the Scales; the two bright stars in Libra—Zubenelgenubi and Zubeneschamali — represented respectively the Southern Claw and the Northern Claw. At the time when Scorpius and Libra formed one constellation there were probably only six constellations in the zodiac. In the time of Confucius the constellation was known as Ta Who, a primeval name for the giant star Antares, which meant Great Fire.

Scorpius, although it is the most characteristic and outstanding constellation of the summer season, is never seen high in the sky from middle northern latitudes, and because of its low declination can be seen in its entirety, tip of tail and all, for only a brief period each night.

Scorpius and Orion are in opposite parts of the sky, the legend being that the gods sent the Scorpion to sting Orion to death because of the giant's overbearing arrogance and conceit. Diana, the goddess of the moon, who was in love with Orion, caused his figure to be placed among the stars, and very carefully saw to it that the Scorpion was located as far from Orion as possible because of their mortal enmity.

The Scorpion boasts as its alpha one of the most beautiful and interesting stars in the entire heavens, Antares. This means "rival of Mars," and was undoubtedly applied to the star because of its red color. Antares is thought today to be one of the largest stars we know, about 330 times the diameter of the sun, and with a volume about 36 million times as great. It belongs with Canopus and Rigel in the class of *supergiants*. It is interesting, though, to note that Antares probably weighs only about 30 times as much as our sun. Therefore, its density must be less than a millionth that of our solar body. Antares is about 250 light-years from the sun. It reaches the meridian and will be seen due south on July 11th at 9 p.m. E.S.T., or 10 p.m. E.W.T.

The region of the sky found in the Scorpion, and pictured on the back cover this month, repays a careful sweeping with binoculars or field glasses, for there are many beautiful objects to be found here. To the northeast of Shaula, the brighter star at the tip of the tail, are to be seen the two star clusters listed on star charts as M6 and M7.

According to the great Herschel the cluster M80, found about halfway between Antares and Beta Scorpii, is the most beautiful and richest mass of stars in the sky. To the east of M80 is a dark spot, one of the many "coal sacks" in the Milky Way.

To the east of Scorpius is Sagittarius, the Archer, also one of the zodiacal constellations. Sagittarius lies largely within the Milky Way, and indeed the brightest part of the galaxy is here. When we gaze at the Milky Way in this section of the southern sky we are looking toward the center of our galaxy, and therefore through a greater collection of stars than when we look in the opposite direction. Our sun is situated not in the middle of the Milky Way galaxy but about one third of the distance from the center to the edge of that great rotating mass of stars.

A clearly defined bow of three stars can be made out in the easternmost part of the constellation almost perpendicular to the southern horizon. Some observers, however, instead of seeing in this group of stars the classic figure of a centaur drawing a bow and aiming his arrow toward the heart of the Scorpion, see a teakettle. Once this teakettle is seen, it is hard to imagine it as anything else. Also in Sagittarius is the famous Milk Dipper, quite appropriately located in the Milky Way.

Sagittarius contains nearly one hundred naked-eye stars, but none brighter than 2nd magnitude. Here many lanes and patches of darkness in the Milky Way are conspicuous, especially near the stars Gamma and Delta. These are like the coal sack previously mentioned in Scorpius, and the still more famous coal sack in the Southern Cross. Actually, these dark spots in the sky are composed of obscuring matter which cuts off the light of whatever stars may be beyond.

ER STARS

ARIAN LOCKWOOD

in the stars in the summer than at any nd in the Hayden Planetarium this month nds concerning the Scorpion and its neigh- ack over for a long-exposure photo of egion to the south of it.

Within the confines of Sagittarius is also a rich region of star clusters well worth observing with binoculars or telescope.

When the night is very clear it is possible to observe from latitude 40° N. the little constellation known as the Southern Crown, Corona Australis, one of the prettiest formations in the sky, although the faintness of its stars and its low declination make it difficult to observe from northern middle latitudes. None of its stars is brighter than 4th magnitude and most of them are even fainter, but it is well worth trying to find.

Rising in the eastern sky in the early evening at the beginning of July, and found progressively farther west at the same hour as the month advances, is the great triangle composed of the three brilliant stars, Vega, Deneb, and Altair. This triangle contains within its borders a section of the Milky Way.

Vega is the alpha of Lyra, the constellation supposed to represent the musical instrument given to Orpheus by the god Apollo. Vega is the fourth brightest star in the sky, and the most brilliant one visible in northern latitudes in the summer time. Its color is pale sapphire.

There are many interesting historical sidelights on Vega. It was the first star, according to *Star Names and Their Meanings* by Allen, to be "submitted to the camera, by the daguerreotype process, at the Harvard Observatory on the 17th of July, 1850." Vega was the pole star about 12,000 to 11,000 B.C., and the motion of precession will make it the pole star again in about 11,500 years, when it will be found 4½ degrees from the celestial pole. It is interesting also as being near the apex of the sun's way, in the general direction in which the sun is traveling through space at the rate of 12 miles a second, carrying all the members of the solar system along with it. Vega is of magnitude 0.1 and is at a distance from the earth of about 23 light-years.

Epsilon Lyrae, the northernmost star of the little triangle which makes a part of Lyra, is a famous double, naked eye for those who have very clear eyesight, and to the telescope it is a double double.

The constellation Cygnus, the Swan, sometimes known as the Northern Cross, lies entirely within the Milky Way, and is one of the most beautiful of all northern star groups. It is much larger than the more famous Southern Cross. Deneb, the bright star at the head of the Cross, or the tail of the Swan (Deneb actually means "tail"), is 19th in order of brightness among the stars of the sky, but still ranks as 1st magnitude. It is a little more than 20 degrees east of Vega. Albireo, the star marking the foot of the Cross, is a gorgeous optical double star as seen through the telescope, one of the components a beautiful heavenly blue and the other a crown gold. It is even sometimes possible to separate this double star with a pair of powerful binoculars, if they are mounted, or can be held steadily enough.

In the section of the Milky Way found in Cygnus are many more of the dark lanes and dark areas. One of the best known of the coal sacks is located between Sadr, the star marking the joining of the two bars of the Cross, and Epsilon Cygni, at the left extremity of the crossbar.

In this quadrant of the Cross also is found the famous star, 61 Cygni, the first star whose distance was accurately measured. Bessel, in October, 1838, made public an announcement of his measurement of the distance of this star, and gave it as 10.3 light-years. This observation was confirmed in 1842-3 by Peters at Poulkovo. The most common modern estimate of the distance of 61 Cygni is about 11 light-years. This seems rather remarkable in view of the fact that the measure of 10.3 light-years, which is in error by less than one light-year, was made over 100 years ago.

Aquila, the constellation in which we find Altair, the bright star which forms, with Vega and Deneb, the triangle mentioned above, is easily identified by the line of three stars, two fainter ones, with Altair in the middle. This row of three is across the Milky Way from Vega, and farther south. A line drawn through Altair and the two faint stars flanking it leads directly to Vega.

At this time of the year in the early evening, the Big Dipper is in the northwestern sky. By following the curve of the Dipper's handle one can locate Arcturus in Bootes, and so on down to Spica in the constellation

(*Continued on page 21*)

The region of Antares and the nebulosity surrounding the star Rho Ophiuchi. In this picture Antares (upper left) is rather faint because of its red color, and many of the other stars are surrounded by nebulosity which they may be exciting to shine. North is at the right.

Amateur Astronomers

THE STARS TELL A SECRET?

A PLEASANT problem for amateurs is provided by one of the oldest references to the constellations. In Book V of Homer's *Odyssey,* we read:

"Odysseus cleverly guided his craft, nor did sleep lower his eyelids while he watched the Pleiades and Bootes, which sets late, and the Bear, called the Wain, which turns in one place, looks at Orion, and never takes a dip in the ocean. Calypso warned him to keep the Bear always on his left."

Without compass, chart, or navigation tables, Odysseus had sailed from Troy, years before, for his little insular kingdom on the west coast of Greece. After terrible adventures on land and sea, he found himself a prisoner on an island near Sicily, perhaps at Syracuse. Radiant Calypso, the goddess who owned the island, offered him marriage and immortality, but he preferred to go home. At long last he was released by order from Mount Olympus. Sailing on a raft, he passed under Italy and across the Ionian Sea. Each night he watched the stars till a tempest wrecked his raft off Corfu.

In what month was this journey made? By consulting a celestial sphere, or by watching the sky, we can discover what perhaps Homer himself did not know, that the time could have been close to what we call Thanksgiving Day. The Pleiades are nearing the west, and Arcturus is rising, at 4:30 a.m. on November 25th.

Homer said that Bootes sets late. It also rises early. Perhaps he knew what every good amateur learns, that the farther north a star or constellation is situated, the longer it remains in the sky.

But could not the time have been late in spring, for on Memorial Day at 4:30 a.m. the Pleiades are rising and Arcturus is setting? No, the stars could not be seen then because on May 30th the sun rises at about 4:45 a.m.

Yet if we should choose an earlier hour between midnight and dawn, we should get other answers — dates in December and January or in June and July.

L. S. COPELAND

ASTRONOMY STUDY GROUP

SINCE the Astronomy Study Group of Portland, Ore., has been meeting at its new location, the attendance has improved and more visitors attend. We are fortunate in having our members take an active part in our meetings, most of them having given a talk; up to the present time we have not had to secure any speaker from outside the organization. Our evenings have all been interesting. The member whose turn it is chooses his or her own subject and gives a talk lasting from one half to one hour. Some give a series of questions for the others to answer; this leads to general discussion, which many times is continued after the meeting is over.

On June 7th, our speaker was Mr. McCroskey, who discussed stellar magnitudes. On July 5th, I shall talk on "The Calendar"; all interested persons are invited to attend this and future meetings.

In May, we discussed distribution of copies of the book, *What To Do Aboard a Transport (Science from Shipboard).* Funds were collected and a committee appointed to see what could be done to place the books on board ships for the use of our troops. Some of us have been buying these books and giving them to individuals.

Inasmuch as several other members have enjoyed joining the program committee at a local restaurant, it has been decided to invite everybody to meet on Friday, the 15th of each month, or on the first Friday after the 15th, at 6:00 p.m. at the Winter Garden Cafe, SW Taylor near 5th. On these occasions, we shall discuss things astronomical and then adjourn to one of our members' observatories, if the sky is clear.

H. J. CARRUTHERS
Astronomy Study Group

DETROIT 20-INCH PROGRESS

BECAUSE of the fact that the technicians of the Northwest Amateur Astronomical Society of Detroit, formerly engaged in making our 20-inch mirror, have been under the pressure of war work, progress on our telescope has been halted for the past 18 months. However, we are again getting under way on this project.

The mirror is ground and polished, ready for the final step of paraboliz-ing. When completed, the telescope will be a Newtonian-Cassegrainian combination with a perforated primary mirror. The mounting will be of the conventional forked type; material for this has been purchased and fabrication is under way. One of our members, E. P. Holleran, has kindly placed at our disposal for this work the equipment and facilities of his manufacturing plant.

A site for an observatory is under discussion and preliminary plans for the building itself are being prepared.

One of our chief motives in the completion of this project is to make it available not only to members of our society, but also to science student groups of the various high schools and the two universities located in Detroit.

NELL T. SPRINKLE
Northwest Amateur Astronomical Society

TACOMA MEETINGS DISCONTINUED

THE MEETINGS of the Tacoma amateurs have been discontinued for the duration, and one officer, Grant Burke, has entire charge of the affairs of the society. His address is Route 3, Box 349, Tacoma, Wash. George Croston, a former president of the group, has retired from business in Tacoma and gone to his farm near Portland, Ore., to live.

Individuals are by no means inactive. W. H. Crump has resilvered the mirror of his large telescope, which is available to members of the society at all times. He, and several of the hardiest, braved the winter snow of Mt. Adams recently, took their telescopes and were well repaid with perfect weather for observing. Prof. Raymond S. Seward has been instructing young aviators in celestial navigation at the College of Puget Sound.

Our youngest member, James Wiborg, has recently finished a 9-inch Newtonian, closed tube, 102-inch focus, with three eyepieces of 100, 200, and 300 power; the instrument measures up to his fondest hopes. It is mounted on a concrete pier and when materials become available the telescope will be housed under a 16-foot dome. Mr. Wiborg is a student at the University of Washington.

EMILY FORD RUSSELL
Tacoma Amateur Astronomers

HERE AND THERE

On page 23 appears the familiar listing "Here and There with Amateurs." Some of these societies have no formal meetings in the summer, but the persons whose names are listed are ready to give information to out-of-town amateurs, and it is always possible that informal stargazing and visiting with fellow amateurs may be in store for a traveler. ED.

BEGINNER'S PAGE

Man and His Expanding Universe — VIII

By Percy W. Witherell

IN THE 18th century many men contributed to the advancement of astronomy by recording the observations of themselves and others and noting apparent anomalies when the then accepted laws of celestial mechanics were applied to the observed data.

John Flamsteed (1646-1719), the first English astronomer royal, published several volumes on the work at the Greenwich Observatory during his 33 years as its director. He was the first to give a true explanation of the causes of the equation of time.

Edmond Halley (1656-1742), when only 20 years old, suggested that transits of Venus could be used to obtain the distance to the sun and the dimensions of the orbits of the planets in the solar system. He believed that comets belonged to the sun's family, but he did not live to see the verification of his prediction of the return of the famous comet that bears his name. He noted the perturbations in the orbits of Jupiter and Saturn due to their mutual attraction; he prepared lunar tables which showed an acceleration of the moon's mean motion over a long period of time.

James Bradley (1693-1762), the third astronomer royal, after 20 years of observing the phenomenon, showed that the axis of the earth describes an ellipse with axes of 18 and 16 seconds of arc in a period of 18 years. He stated that this *lunar nutation* was caused by the gravitational action of the moon. Bradley also discovered the aberration of starlight, whereby stars appear displaced ahead of the earth because of its forward motion in its orbit; the amount of the aberration was also a proof and a measure of the finite speed of light.

Nicolas Louis de Lacaille (1713-1762) computed the places of 1,942 stars in the southern hemisphere and prepared a table of refractions.

We have mentioned how Newton was unable to check his theory of gravitation in the case of the moon because of the inaccuracy of the length of a degree of latitude on the earth's surface. The French Academy of Sciences decided to measure the length of a degree at the equator and at an extreme northern location. This was done in Peru and Lapland and the results proved the flattening of the earth at its poles. In this same connection, Pierre Bouguer (1698-1758), in his *On the Figure of the Earth*, gave data on the lengths of pendulums that would beat seconds at various locations on the earth, and also the effect on a plumb line of nearby mountainous masses. These findings are basic to the methods in use today in determining the radius of the earth at different locations.

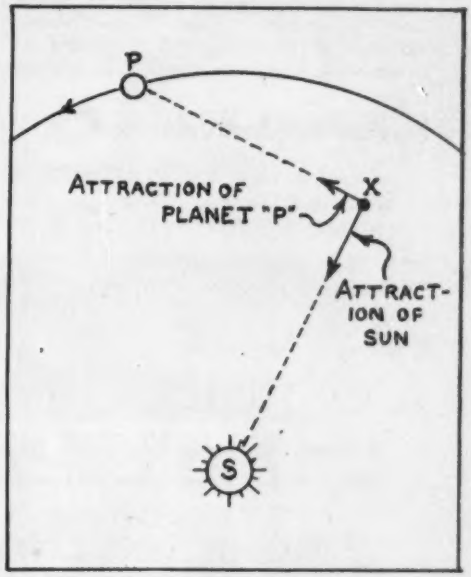
Sir William Herschel (1738-1822), often called the "father of modern astronomy," increased the known size of the solar system by discovering Uranus in 1781, and later found two of its satellites. Herschel constructed many reflecting telescopes with speculum metal mirrors and he was an indefatigable observer. From his studies of the distributions and motions of the stars, he stated that the sun was moving in the direction of the stars in Hercules, and he pictured the Milky Way as a flattened system of millions of stars. His great telescopes opened new fields of investigation, for with them he discovered many double stars and distant nebulae and star clusters.

Giuseppe Piazzi (1746-1826) was in the habit of making several observations of each star included in his great catalogue of 6,748 stars. He noticed that an 8th-magnitude star changed its position between his observations and thought it was a comet; its lack of nebulosity and its retrograde motion finally proved it a planet. Thus he discovered Ceres, the first of the asteroids. (See page 3.)

Newton's law of gravitation could be demonstrated mathematically for two bodies in a satisfactory manner. When it was applied to the numerous large objects in the solar system which were affecting each other it became a difficult problem. Many years of laborious calculations by several eminent mathematical astronomers were required to discover some practical methods for solving this important problem. Jean le Rond d'Alembert (1717-1783) solved the "three-body" problem of the moon, earth, and sun, and determined the relative masses of the earth and moon. He devised a simpler method of determining the mutual effects of any planet and its satellites, and gave a method of computing the attraction of any spherical body even if composed of strata of different densities—this being the case for most planets.

Leonhard Euler (1707-1783) discovered the periodic nature of the mutual perturbations of the planets, showing that the elements of the orbits of Jupiter and Saturn return to the same values after some 30,000 years. Joseph Louis Lagrange (1736-1813) presented a solution for six bodies in considering the problem of the sun, Jupiter, and its four then known satellites. He also showed that the mean motions and mean distances of the planets from the sun are invariable, thereby confirming Kepler's third law. In consequence, it is demonstrated that all the changes of the orbits in the planetary system are periodic, that the system contains no principle of destruction within itself and will endure until disrupted by some outside agency.

Pierre Simon de Laplace (1749-1827) placed the universe on a sound basis in his masterly *Mécanique Céleste*. He showed that the apparent discrepancies that had troubled supporters of Newton's laws were really its vindications when properly analyzed. In his own words, he gave a complete solution to the great mechanical problem of the solar system.



This diagram represents the famous three-body problem. The object X is attracted simultaneously by the sun at S and a planet at P. Both X and the planet are in motion; only the sun may be considered stationary. Consequently, the distance of X from both planet and sun and their respective attractions for X are continually changing; the problem of expressing future positions of X is therefore very involved.

Not only had these great mathematicians demonstrated the stability of the universe and the general application of the physical laws governing its motions, but they had established the need for careful observations and exact methods of computation that did not ignore any apparent divergences from predicted phenomena. In so doing, they also perfected the calculus and founded modern mathematical astronomy.

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BOOKS AND THE SKY

MARINE AND AIR NAVIGATION

John Q. Stewart and **Newton Lacy Pierce.** Ginn and Company, Boston, 1944. 472 pages. $4.50.

MANY of us who were called upon to teach navigation to men in the armed forces and to college students, shortly after Pearl Harbor, were confronted with the difficult task of choosing a text. Dutton's **Navigation and Nautical Astronomy**, the standard text in the field, was too long and in a way too involved for the needs of a short course, while Bowditch's **American Practical Navigator**, designed more as a reference treatise than a text, was not quite suitable, nor was Mixter's **Primer of Navigation**, a fine practical book, emphasizing the drill method of learning.

During the last two and a half years, however, a great number of books on navigation have been published. In spite of this the problem of choosing a text still existed until the present appearance of two excellent books this spring. They are: **Marine and Air Navigation**, by Stewart and Pierce, the book under review, and **Basic Marine Navigation**, by Bok and Wright. These are two scholarly books, the products of experience in the present-day teaching of the subject.

The Princeton astronomers have wisely chosen to include under one cover both marine and air navigation. Often the instructor of marine navigation finds that his class is interested in air navigation practice and in the fact that both branches of navigation deal with the same fundamental problems.

The usual subject material, piloting, dead reckoning, radio navigation, and celestial, is covered in a straightforward manner and well illustrated with figures and numerical examples. Mathematics, that is, trigonometry, is introduced only when it is found necessary.

The subjects of currents, winds, relative motion, maneuvering, and radius of action have been fully treated in three chapters. The presentation is clear and most thorough and the illustrative material is given in full by means of standard maneuvering board sheets. In nearly every case, a corresponding navigational plot is given which both student and teacher will appreciate.

The chapter on tolerances is a welcome inclusion, as is also "The History of Navigation." As a matter of fact, throughout the text historic references and narratives are presented which single out the book from the drill type of text. Necessary drill material, however, is not neglected. Two hundred and seventy-five drill problems with answers are given at the back of the book.

One somehow feels that the magnetic compass is not given sufficiently extensive treatment in theory or application. The deviation table is mentioned, but no example of such a table is given nor a description of the nature of observations needed for its construction. The brief reference made in the chapter on azimuth to obtaining the deviation by astronomical observations seems quite insufficient and too far removed from the chapter on the compass. The student is given no opportunity to compute compass course from true course by the deviation table or similar means.

Roughly a fourth of the book is devoted to celestial navigation and the sextant. The authors wisely include in a short chapter a preliminary summary of the subject, thus unfolding the trend of the succeeding chapters. This is a worthwhile procedure since the student likes to know where he is heading, and besides, the material may be used later for review purposes.

It seems unfortunate that the chapter on "Time and the Almanac" lacks an adequate definition of civil time. Civil time is really defined in a much later chapter. A paragraph or two in the beginning would have disposed of the matter nicely.

In their exposition, the authors show that celestial navigation can be taught quite satisfactorily without the use of sidereal time. The **Air Almanac** and the solution for the line of position by means of H.O. 211 and H.O. 214 have been justly emphasized. It seems that in order to save the student the trouble of mastering an additional term the authors have tried to avoid the use of the meridian angle (**t**) and have defined local hour angle as a measurement in the direction of east or west. This might have proved satisfactory if **LHA** is always designated E or W or if it is stated that in this case the measurement is so considered. However, this procedure was not followed completely throughout the book. As for example, **ST** = **LHA** object + **RA** object. It is the opinion of the reviewer that since **GHA** is defined as a measurement in the direction of west, **LHA** should be defined likewise. The student then would associate time with **HA** in such a way that with increase of the one he would see a corresponding increase of the other.

The student in navigation enjoys an occasional diversion to astronomy and is usually eager to learn something about the planets, the stars, and the

NEW BOOKS RECEIVED

BASIC MARINE NAVIGATION, *Bok* and *Wright*, 1944, *Houghton Mifflin*. 422 pages. $4.50. Kit of Practice Materials, $1.70.

This text in marine navigation emphasizes the practical aspects of coastwise piloting, compass and sextant, and celestial observations. It includes a thorough discussion of navigation in emergencies, 150 practical problems with answers, and a complete set of Ageton's tables.

galaxies. The chapter on "Astronomy for Navigators," besides reviewing and treating more in detail the systems of co-ordinates and the three types of local times, gives some descriptive astronomy. Here apparent solar time (AT) is defined as the hour angle of the sun and a corresponding definition is given for mean time. This is unfortunate, since these definitions are not in agreement with the **Nautical Almanac**. For example, the equation at the bottom of page 372 is bound to confuse the student wishing to obtain AT from the tabulated value of the equation of time given in the almanac.

The book is in quarto form with pages divided into two columns for easy reading. The large pages also provide room for the reproduction of charts and similar material on a relatively comfortable scale. The illustrations, many full page and in colors, are packed with interesting details and are truly attractive. The illustration given in Figure 23-1, page 309, appeared in **Life** magazine some two years ago and was promptly reproduced in many books on navigation in spite of the fact that it is definitely misleading. The two cones should be cylinders. The caption in this book attempts to correct this error bu' an illustration usually has more weight with the student than its corresponding caption.

There is no doubt in the mind of the reviewer of the overall merit of this book and it is hoped that the authors might consider, in the light of the above remarks, some changes in a future edition.

Navigation has a definite place in the liberal arts curriculum when properly presented. This can be accomplished by a correct balance between discipline, encouragement to quantitative thinking and to the imagination, and presentation of historical background. **Marine and Air Navigation** provides such a balance.

J. J. NASSAU
Case School of Applied Science

LEARNING TO NAVIGATE

P. V. H. Weems and **W. C. Eberle.** Pitman Publishing Corporation, New York, 1943. 135 pages. $2.00.

LEARNING TO NAVIGATE, now in its revised second edition, adds another book to the ever-growing list of navigation publications produced under the Weems stimulus and guidance. The book is short, but, as with all of the Weems books, the style is engaging and inspirational, with a healthy disregard for ingrained tradition. Every prospective navigator should have at least one Weems book, if for no other reason than to see how this pioneer, who speaks with unquestionable authority in the field, slashes out elements which are outmoded or which can be eliminated, thus arriving at the vastly simplified Weems system of navigation. For this service Weems deserves everlasting recognition and respect.

For the most part this book has been assembled from elements to be found in the other Weems books, condensed and presented in the style of Weems, with no attempt at formal, smooth organization. As always, the best feature is the repeated inspirational assurance, implicit or direct, that navigation can be exciting and simple and that graphical methods are good enough. As always, one must make mental allowance for the fact that the Weems system, though a completely satisfactory method, is not generally accepted in toto. As a single example, Weems continues to stress the **Line of Position Book** method of celestial navigation instead of H. O. 211 (Ageton), which has been more generally adopted by the Army and Navy for the equivalent purpose.

FITZ-HUGH MARSHALL, JR.
Buhl Planetarium

AN INTRODUCTION TO NAVIGATION AND NAUTICAL ASTRONOMY

Shute, Shirk, Porter, and **Hemenway.** The Macmillan Company, New York, 1944. 457 pages. $4.50.

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(*Continued on page 19*)

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GLEANINGS FOR A.T.M.s

An Improved Pitch Lap

IT IS within the ability of the amateur telescope maker to produce a perfectly polished surface on his first mirror, on a par in that respect with the work of the best opticians. Where the tyro's mirror will suffer by comparison is in the figure on this reflecting surface. Bell, in **The Telescope**, states that the aberration blur from a spherical 6-inch mirror of ratio f/10 is about 20 times the width of the Cassini division in Saturn's rings, meaning that the mirror would fail to clearly define it. One may then wonder what conditions occur in some telescope mirrors, with their hyperbolic shapes, zonal errors, and so on.

These faults can be attributed chiefly to an excusable lack of skill on the part of the amateur, and the exhausting of his patience in attempting to combat the natural (or unnatural) perversity of the pitch lap on which the mirror is polished and figured. Those who have made telescopes at home will recall the almost interminable hours of working and testing, and the amazing and discouraging succession of impossible figures that were revealed under the Foucault test. But since all things must come to an end, the usual conclusion has been a sort of compromise being effected with the lap, and an inferior mirror mounted in the telescope. And a most prevalent defect on such mirrors is a turned-down edge, which, according to its extent, may scatter as much as 10 per cent of the light around the field.

In the telescope classes conducted at the Hayden Planetarium, students are expected to complete an excellent mirror in about 20 sessions. Obviously, procedures must be adopted that will keep the worker from wandering far afield.

Greatly facilitating the figuring process is the employment of a lap similar to one developed by Dr. Henry L. Yeagley, of Penn State College, which was described in The SKY several years ago (March, 1938). It consists of rows of small round wafers of pitch spaced progressively farther apart toward the center, and so distributed as to preclude the possibility of zones. Because of the small separation between the wafers, pitch which is on the hard side must be used. Contact is more readily obtained and kept, and a somewhat longer polishing stroke is permitted than on the common channeled lap. And because of the good contact, and the reservoir of rouge-water mixture surrounding the facets, which tends to equalize temperature and retard evaporation, turned edge is almost completely absent. With no effort at all toward figuring, mirrors being polished on this lap will, almost invariably, show a fine diffraction ring around the edge. The surfaces generally appear smooth, slightly oblate, and can be rapidly brought to a spheroidal figure, after some attention to contact, by a slight lengthening of stroke. Then a blending of the usual long and elliptical overhang strokes, briefly used, is about all there is to the parabolizing.

To make the lap, a perforated rubber mat is used as a mold. The size of the holes, and arrangement of the pattern, is arbitrary. But they must be close together, about 1/16 of an inch is good. Experimentally, I perforated one mat with ½-inch holes, ⅛-inch separations, and the lap formed from it left an impress of its pattern on the mirror which no stroke, or blending of strokes, could erase. Similar mats, but with the separations spaced 1/16 of an inch apart, have been in service for two years, with the excellent results outlined above. Occasionally, however, mirrors under test would show the barest suggestion of the facet pattern, not enough to affect their optical qualities, but nevertheless disturbing. Alex Singer, our secretary, suggested that the rows of facets (horizontal in the diagram) be curved, thereby causing the diametric strokes to be carried off their tracks. This seemed reasonable, and after experiment, the pattern herein described, and illustrated on the front cover, was adopted for a 6-inch mirror. The most effective remedy for the above condition may be a slight variance in direction of each stroke, and not more than four or five successive strokes on a diameter.

Good sheet rubber, at least seven inches square, and 1/16 to ⅛ inches thick, that will lie flat, will do. It is assumed that a ⅜-inch saddler's punch or cork borer can be obtained, but the sizes vary somewhat, so measure the diameter exactly, and space the lines in the pattern accordingly. A cardboard template, cut on a radius of about two feet, serves as a ruler to draw the "horizontal" arcs in the pattern, which should be drawn on a thin sheet of paper, following the plan shown in the figure. At the intersections of the horizon-

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tal and vertical lines, draw circles ⅜ inches in diameter. Then select a center, and describe a 6-inch circle, endeavoring to encompass as many whole small circles as possible, thus reducing to a minimum the number of patches to be put in later.

Spread a thin coat of mucilage on the rubber sheet and press the pattern smoothly onto it. When dry, lay it on a thick magazine, set the punch, or borer, over a small circle and cut out the hole with a single sharp blow of a hammer, or twist of the borer. When all the perforations are made, cut up some of the wafers for patches for those holes overhanging the 6-inch circle, and glue them into place with rubber cement. When set, trim the mat to within about ¼ inch of the holes.

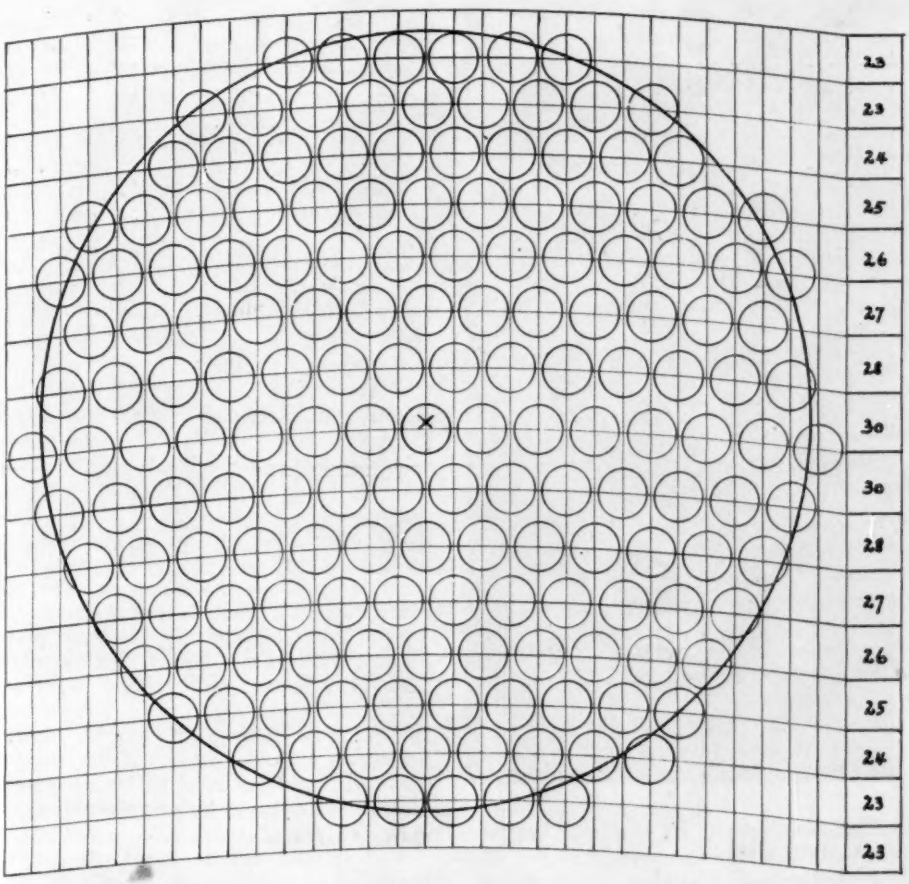
As already stated, the pitch should be hard, so that the facets will not flow together under the work of polishing. About half-and-half rosin and pitch should make a good mix. Be sure to stir it thoroughly before pouring. Have the mirror and tool in a pail of hot water while the pitch is melting. Lay the mat on a clean pane of window glass, and paint it all over with glycerin or a thick mixture of rouge. When the pitch is melted, remove and dry the mirror. Lay it face up on the pane of glass, and paint surface and sides with the rouge. Place the mat on the mirror, then remove the tool from the water and dry. Pour the hot pitch over the rubber mat, completely filling all holes. Carefully centering the warm tool over the mirror, convex side down, firmly press down onto the hot pitch, squeezing the excess out over the side. In a few seconds, invert the disks, and slide the mirror off. After a minute or two, the rubber mat can be lifted from the lap with a gentle stretching and pulling, carefully done, so that the edges of the facets do not become broken. Trim around the edge of the lap, flush clean of pitch fragments, and after a short pressing period, an efficient, "tailored"-looking lap is ready for polishing. We, at the planetarium, first coat our laps with beeswax, which results in a more rapid, sleek-free polish.

By working on a sheet of glass, rather than paper, all of the excess pitch can be recovered and returned to the pot. After the first polishing spells, a figure of the lap may be found on the mirror, but this will disappear as the knack of blending the strokes is acquired, and the facets spread out under the pressure of work. Should they sink down and merge together under prolonged working, or because the pitch is too soft, the lap can be chipped off and a new one made in a jiffy.

Lou Lojas, the "old professional," prefers to pour about ¼ inch of pitch onto the cold tool, and when it is in a semi-cool, thickened state, to lay the mat on it and press it into the pitch with the mirror, thus shaping the lap and forming the facets. A thin film of soapy water had best be used on mat and mirror. This method is less fussy, though it requires more pitch, as well as some familiarity with the stuff, or it may result in disappointment.

By way of apology for all this work just to produce a single lap, the reader is assured that its use will pay dividends in hours saved in figuring, and will probably result in a better figure than might otherwise be obtained. And it may be used many times.

ALLYN J. THOMPSON
Optical Division, A.A.A.
Hayden Planetarium, N. Y.



The pattern of the mat for a 6-inch lap, with ⅜-inch perforations. Vertical lines are 7/32 of an inch apart. Figures at the right indicate distance between horizontal arcs in 64ths of an inch; the circle was six inches across before reduction in engraving.

BOOKS AND THE SKY

(*Continued from page 17*)

tion. Fundamentally, it is a textbook designed for class use with students who have at least a moderate background in trigonometry. However, it is entirely suitable for home study, and a mathematical appendix summarizes the trigonometry which is used. Due to the inclusion of a large number of tables and extracts of tables from standard navigation references, the book is about as complete within itself as is possible, requiring a minimum of accessory charts and tables. Tables in the appendix include four-place logarithms and logarithmic trigonometric functions, H. O. 211 (Ageton), meridional parts, and excerpts from H. O. 214, the **Nautical** and **Air Almanacs**, and Bowditch. Following the style of Dutton's **Navigation and Nautical Astronomy**, the last chapter is devoted to aerial navigation, but the approach of the book is fundamentally that of marine navigation.

This book may be compared with Dutton's now classical textbook prepared for use at the Naval Academy, for the point of view and emphasis is strictly the same despite the fact that the organization and the details of the treatment are entirely new. This new work is exactly what its name implies, **An Introduction to Navigation and Nautical Astronomy**, although its authors are not associated with Dutton. There are many who will prefer to use Dutton's more expanded source book itself, especially since its wartime price is less than half that of this book. However, this new volume is much more of a text and much simpler to use in classes in which the average background is less than that of the students at the Naval Academy. The organization is better for classroom purposes. Adequate problems with answers are included. Commonplace illustrations and analogies are employed.

FITZ-HUGH MARSHALL, JR.
Buhl Planetarium

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

JUPITER AND THE LUNAR ATMOSPHERE

BY JESSE A. FITZPATRICK

SEVERAL correspondents bring up a subject of considerable interest. We shall consider the main parts of two letters first and then look back to the days of William H. Pickering and his photographs of a Jupiter occultation in 1892.

Walter H. Haas, of Upper Darby, Pa., writes: "The occultation of Jupiter by the moon on April 30th-May 1st was observed with the 18-inch refractor of the Flower Observatory, using 150x. The seeing was poor, as usual in Upper Darby, while the sky was clear, not as usual in Upper Darby. When the planet emerged from behind the **bright** limb of the moon, a hazy gray band concentric with the lunar limb was seen across the face of Jupiter. The angular width of the band was estimated to be three seconds of arc.

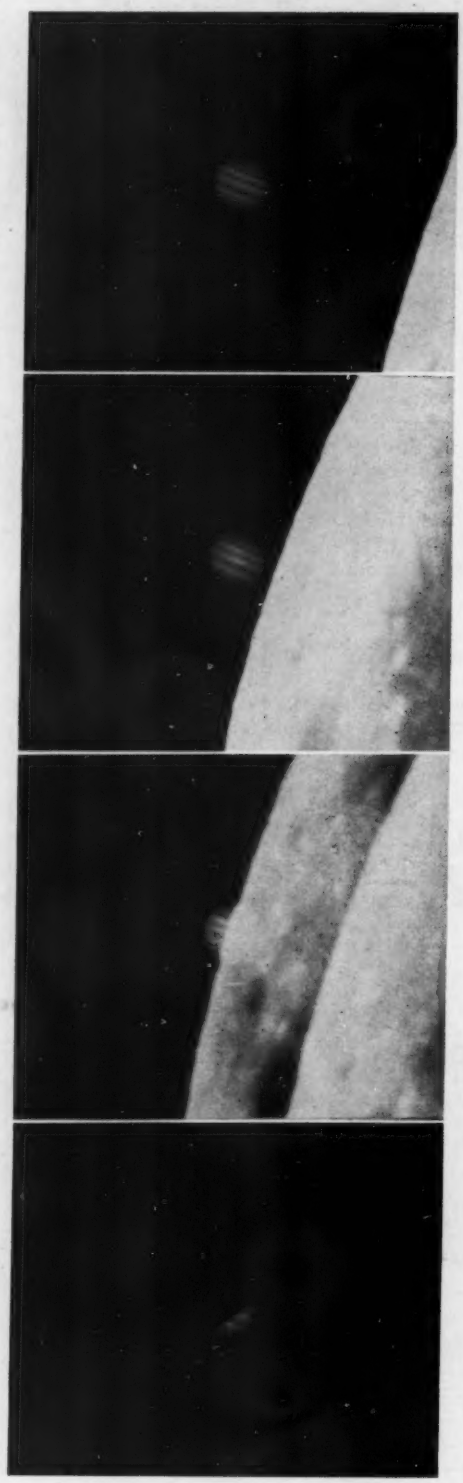
"This band was about as easy to see as either of the temperate belts on the planet. It certainly **looked** real. I saw nothing similar during immersion at the **dark** limb. Such a band was seen by at least one other observer at the recent occultation and by at least several observers at the January 13th occultation.

"I am greatly interested in this marking because of the interpretation that W. H. Pickering put upon it. (See "The Occultation of Jupiter," Sept. 3, 1889, **Sidereal Messenger**, 9, 148, 1890; "The Lunar Atmosphere and the Recent Occultation of Jupiter," **Astronomy and Astrophysics**, 11, 778, 1892.) Of course, there may be other explanations. It does appear most desirable, though, to examine data relating to this mark. Presumably, occultation observations are frequently reported to **Sky and Telescope**, and I should be very grateful for any reports of observations of this kind which may reach you."

Somewhat later a letter from Cyril G. Wates, of Edmonton, Alberta, Canada, reached us. In it he writes:

"I am writing to you with reference to possible evidence of a lunar atmosphere, as indicated by observations of the recent occultations of Jupiter. I have received reports, either directly or indirectly, from the following observers: White — Chapman's Camp (near Kimberly), B. C.; Campbell — Edmonton; Wates — Edmonton; Morgan — Montreal, P.Q.; Haas — Upper Darby, Pa.; Johnston — Rochester, N. Y.; Theodore Hake — York, Pa.; Hake (above's brother)—York, Pa.; Hilliard—Worcester, Mass.

"Three kinds of appearances were observed. On January 13th, Hilliard and Campbell observed no dark band at all, while White and Morgan observed a gray band across Jupiter tangent to the moon. At the April 30-May 1 occultation, however, Johnston and Haas observed the same band. The third appearance, observed by me in January and the Hake brothers in April, was that of cusps at the ends of the band, near where Jupiter's limb touched that of the moon. The band was estimated at three to five seconds in width, and the cusps seemed to me to be about twice the width of the band.



The occultation of Jupiter, August 12, 1892, photographed by W. H. Pickering at Arequipa, Peru, using the 13-inch telescope of Harvard's Boyden station. The last picture shows Jupiter emerging from the dark limb of the moon. These are contact size from original negatives.

"Great interest attaches to the fact that the Hake brothers were working independently, and that they had **not heard** of my observation of the first occultation. Therefore, their observation of the cusps seems to confirm the real existence of these features. The cusps were so obvious to me that I cannot imagine any experienced observer failing to see them. This remark seems to apply also to Theodore Hake and his brother.

"I am told that Pickering observed the band more than 50 years ago, but made no mention of cusps. Doubtless you can confirm this.

"My theory of the cusps was that they were caused by vapor rising from the floor of a ring plain seen in profile at the point of contact, vapor from the floor causing the band and from the walls, the cusps. But the observation of the cusps by the Hake brothers seems to ruin my theory, as it would be a very strange coincidence if contact took place during the second occultation, as seen from York, on the floor of another ring plain.

"The fact that the band was seen by eight out of 10 observers at the bright limb, but that all agree there was no trace of it at the dark limb, is easily explained on the theory that solar heat evaporates ice or CO_2 during the lunar day, but that the vapor condenses at once when the sun sets. There is, of course, the possibility of some optical illusion, but it seems very unlikely.

"Dr. C. S. Beals, of the staff of the Dominion Astrophysical Observatory at Victoria, and I have suggested, independently, that the existence of a tenuous lunar atmosphere might be confirmed by means of a spectrogram of a bright star just before occultation. Dr. Beals believes that the light of the moon would not interfere with the taking of such a spectrogram.

"I am in the hope that you may appeal for more observations from amateurs and others, and thus get as much evidence on the subject as possible."

In the second of Mr. Haas' references, the pictures appearing on this page were reproduced, and when sending the accompanying article discussing the possible existence of a lunar atmosphere, Prof. Pickering, then in Peru, wrote:

"The 2nd, 3rd, and 4th [pictures of a series] were taken before the occultation. The latter [third in the pictures here], unfortunately, had a double exposure, two images of Jupiter being taken one over the other. Nevertheless, the dark band referred to in my paper can I think be faintly detected even upon the print."

And in the article itself, he states that a dark band three seconds of arc wide was also observed visually by a Mr. Douglass, using a 5-inch refractor with 75x. Furthermore, on emergence at the dark limb, Jupiter did not show this dark band. He writes: "Since this

band was photographed it cannot well be due to an optical illusion, and since it was seen it can hardly be classed as a photographic defect — unless indeed we suppose that by a coincidence both conspired to produce the same result."

Other facts brought out in this article concern reported extensions of the moon's crescent tips; slight flattening of Jupiter in the direction of the moon when near its limb; lunar surface atmospheric pressure of 1/250 of an inch of mercury; combustion of meteors in the lunar atmosphere; moon's atmosphere more dense than earth's at altitudes above 53 miles in each case; velocity of escape of gases and retention of the particles of gas making an atmosphere.

Although the original negatives of the 1892 occultation were found in excellent condition, and although the dark band can be "faintly" seen by transmitted light on the negative, it does not show up in the prints from which these reproductions have been made; in the case of the double exposure the image of Jupiter is apparently somewhat overexposed.

AN ANNULAR ECLIPSE

AMERICAN and British soldiers and sailors in the Far East will witness a partial eclipse of the sun on July 20th. Those who may find themselves in certain parts of eastern Africa, the Indian Ocean, India, and the waters north of New Guinea, will observe an annular eclipse with a maximum duration of the central phase of 3 2/3 minutes. In most of Australia, the partial eclipse will be seen near sunset, and for eastern Africa and Madagascar the partial phase occurs at sunrise. The countries of the Near East, lower Russia and Siberia, China, southern Japan, and the East Indies will also view a partial eclipse.

The central line, along which the annular phase may be seen, crosses India near Bombay and south of Calcutta, traverses Thailand and Indo-China, thence passes over Mindanao Island in the Philippines.

OCCULTATIONS FOR TEXAS

Predictions are for longitude 98° 0′.0 W., and latitude 30° 0′.0 N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, a and b quantities in minutes, and position angle in degrees, at immersion; G.C.T., a and b quantities, and P.A., at emersion.

July 3, 81 B Oph fol., 6.3; 23:35.4, +0.1, —0.4, 134°; 0:32.1 (4th), —1.0, +1.2, 265°.

July 8, 30 Cap, 5.4; 9:06.2, —1.5, +1.7, 33°; 10:12.6, —2.5, —1.1, 283°.

July 9, 50 Aqr, 5.9; 13:09.1, —0.8, +0.1, 60°; 14:12.3, —0.5, —0.3, 249°.

July 10, Chi² Aqr, 4.6; 11:17.0, —0.9, +2.2, 22°; 12:19.7, —2.4, —0.9, 276°.

July 29, 13 Lib, 5.8; 2:01.7, —3.1, 0.0, 79°; 3:14.1, —1.5, —2.9, 333°.

July 30, Eta Lib, 5.6; 1:39.4, —2.6, —0.4, 102°; 3:09.8, —2.1, —1.7, 306°.

The predictions, computed voluntarily by Miss Tecla Combariati and J. Lynn Smith, of the U. S. Naval Observatory, are similar in form to those given in the **American Ephemeris** for 1944, pages 365-372.

Immersions at the dark limb (while the moon is waxing) are most desired. Reports should include the exact time of the phenomenon, and the observer's precise latitude, longitude, and elevation.

OCCULTATIONS—JULY, 1944

Local station, lat. 40° 48′.6, long. 4^h 55^m.8 west.

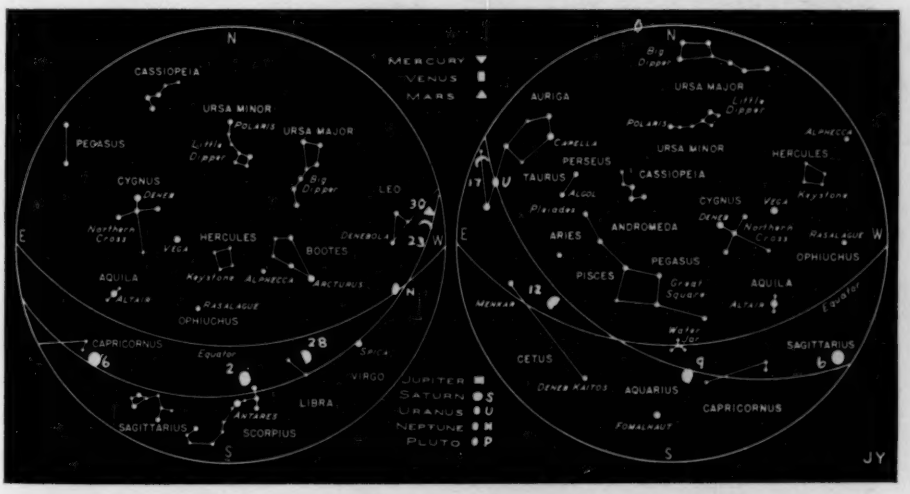
Date		Mag.	Name	Immersion	P.*	Emersion	P.*
July	1	6.7	BD —9° 3945	1:31.9 a.m.	96°		
	3	6.3	81 B Ophiuchi	8:00.0 p.m.	65°	8:56.0 p.m.	327°
	8	5.4	30 Capricorni	5:42.6 a.m.	39°	6:41.3 a.m.	279°
	29	5.6	Eta Librae	10:37.7 p.m.	49°	11:23.0 p.m.	343°
	30	7.1	BD —18° 4302	11:26.1 p.m.	48°		

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

PHASES OF THE MOON

Full moon	July 6, 0:27 a.m.
Last quarter	July 12, 4:39 p.m.
New moon	July 20, 1:42 a.m.
First quarter	July 28, 5:23 a.m.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 4:30 a.m. on the 7th of the month, and at 3:30 a.m. on the 23rd. At the left is the sky for 10:30 p.m. on the 7th and for 9:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, Venus, Saturn, and **Uranus** are too close to the sun for observation.

Earth, at aphelion on July 3rd, will be 94,554,000 miles from the sun.

Mars and **Jupiter** are both in Leo. They will be in conjunction at 4:00 a.m., July 5th, with Mars 15′ to the north, but this conjunction will be invisible from the Western Hemisphere.

On July 9th at midnight, Mars will be in conjunction with and 42′ north of Regulus, while on the 20th at 8:00 a.m., Jupiter will be in conjunction with the same star, and 30′ to the north. Proximity to the sun makes these comparatively unfavorable events to observe.

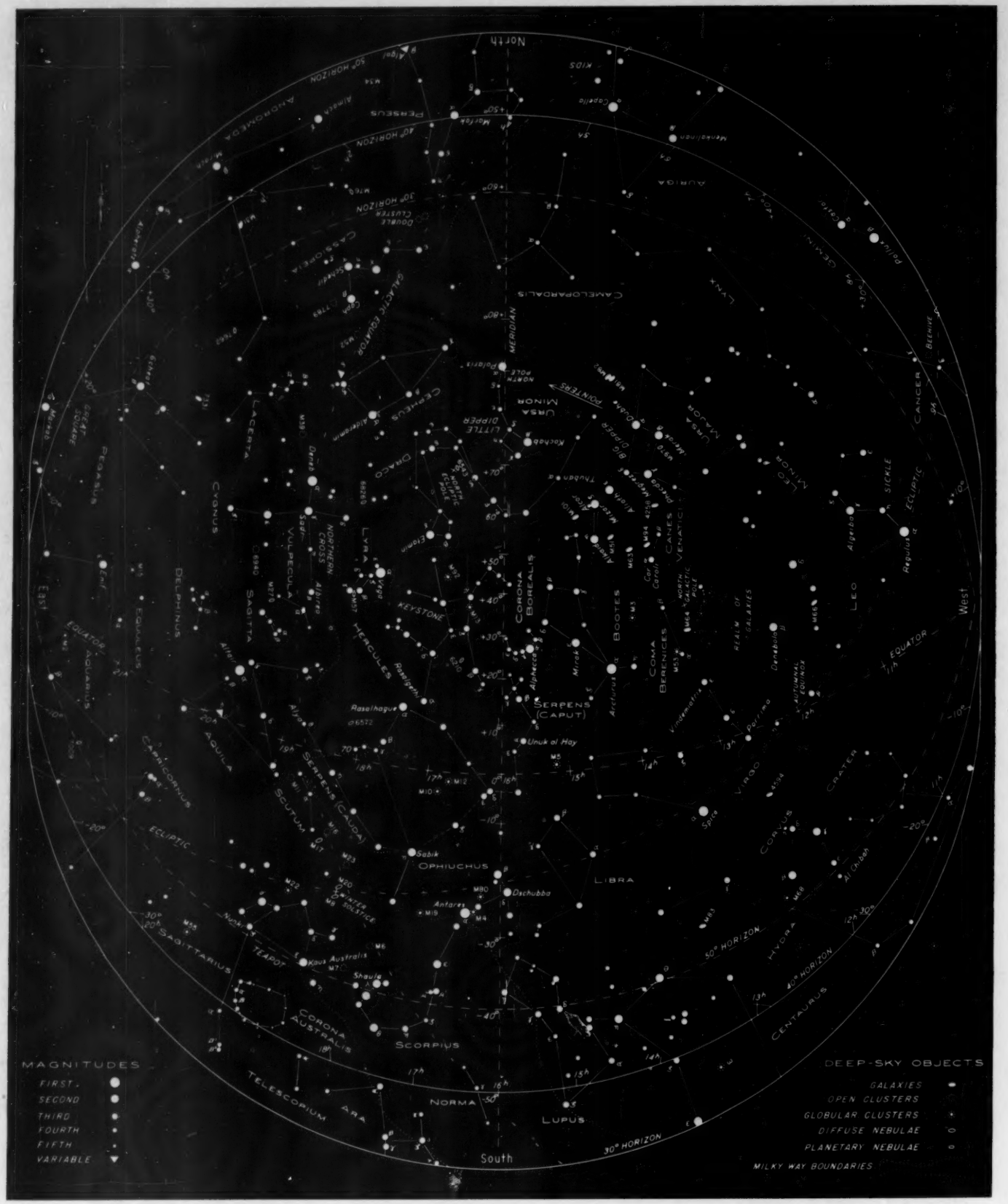
Neptune is in Virgo.

SUMMER STARS

(*Continued from page 13*)

Virgo. To the east of Bootes is the small and charming constellation of Corona Borealis. Rising in the east about midnight appears the Great Square of Pegasus, with its beautiful and symmetrical figure. By following the two westernmost stars of the Great Square on a line to the south, the observer can find the bright star Fomalhaut just above the southern horizon and below the constellation Aquarius.

In the dawn of the July sky we glimpse the first return of our old favorites of winter, for there in the east, just before the sun's rising, come the Pleiades, and following soon after and visible in August is the stately figure of Orion. But summer goes, and winter follows, and there will always be another summer, bringing back again the good star friends of yesteryear.



DEEP-SKY WONDERS

AMONG marvels for observation in the July skies are the objects listed here. The informal descriptions portray appearance in common telescopes.

Scorpius. M80, $16^h\ 13^m.8$, —22° 51′; globular, small and dim for amateurs. M7, $17^h\ 47^m.3$, —34° 47′; cluster of 50 stars; larger than nearby M6, also a cluster of 50 stars.

Sagittarius. M17, $18^h\ 15^m$, —16° 13′; beautiful Horseshoe or Omega nebula; resembles a swan with a star for its eye.

Serpens Cauda. M16, $18^h\ 13^m.2$, —13° 49′; fan-shaped cluster of 55 stars.

Ophiuchus. M19, $16^h\ 59^m.2$, —26° 11′; small globular.

Scutum. M11, $18^h\ 45^m.7$, —6° 23′; wonderful cluster of 200 apparently small stars, with an orange sun near the center.

L. S. COPELAND

STARS FOR JULY

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

Here and There with Amateurs

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups. The asterisks denote societies whose members receive *Sky and Telescope* as a privilege of membership.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	*Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Homer D. Ricker, Harvard Observatory
"	A.T.M.s of Boston	2nd Thu.	8:15	Sept.-June	Harvard Obs.	Ernest Smith, 158 Warwick St., Lowell
BROOKLYN, N. Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:00	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & Observers	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C.T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	*Burnham A. S.	2nd, 4th Tue.	8:00	Sept.-June	La Salle Hotel	Miss W. Sawtell, 928 N. Harvey Ave.
CINCINNATI	*Cin. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	Northwest A.A.S.	1st, 3rd Tue.	8:00	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	Duluth Ast. Club	Meetings suspended				W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	Indiana A.A.	1st Sun.	2:00	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	Joliet A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Mrs. Robert L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A.S.	3rd Tue.	8:00	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct. *Taylor* 4157
MADISON, WIS.	Madison A.S.	2nd Wed.	8:00	All year	Washburn Obs.	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	Milw. A.S.	1st Thu.	8:00	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	Pop. Ast. Club	2nd Wed.	7:30	Oct.-April	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	J. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. of N. Orleans	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	Junior Ast. Club	Alt. Fri.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	A.A.S. of Norfolk	4th Tue.	8:00	All year	Central Y.M.C.A.	P. N. Anderson, 635 W. 29th St.
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	Eastbay A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. of F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*Rittenhouse A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	*A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 837 Estella St.
PONTIAC, MICH.	Pontiac A.A.A.	2nd Mon.	8:00	All year	Private homes	John Setlow, Jr., 593 S. Paddock St.
PORTLAND, ME.	A.S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	*Ast. Study Group	1st Wed.	8:00	All year	No. 9 Pacific Bldg.	H. J. Carruthers, 427 S. 61 Ave.
PROVIDENCE, R.I.	Skyscrapers	1st Wed.	8:00	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A.S. of Nev.	4th Wed.	.....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN ANTONIO	San Ant. A.A.	3rd Mon.	8:00	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SAN DIEGO, CAL.	Ast. Soc. of S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	R. M. Lippert, Box 41, N. Park Sta.
SCHENECTADY	S'tady Ast. Club	3rd Mon.	8:00	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
TACOMA, WASH.	Tacoma A.A.	Meetings suspended				Grant Burke, Route 3, Box 349
TULSA, OKLA.	Tulsa A.S.	2nd Tue.	.....	All year	Holland Hall	V. L. Jones, 4-8462
WASHINGTON, D.C.	Nat'l. Cap. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Miss D. Harris, 1621 T St., N.W., *Du.* 4200
WICHITA, KANS.	*Wichita A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
YAKIMA, WASH.	Yak. Am. Astr'mers	3rd Tue.	7:30	All year	Y.M.C.A. Lounge	C. A. Zumwalt, 1019 Pleasant

★ ★

Planetarium Notes

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *July*, BY ROCKET TO THE MOON.

No one has ever predicted that the airplane could take us on a trip to Mars. The lack of air between the planets precludes that, but for a ship propelled by rocket motors no air is needed. In this sky show we see just what the principle of the rocket is, and how we have produced rocket guns and rocket planes in the present war. Then we board an imaginary passenger rocket ship of the future, which whisks us swiftly to the moon—to the floor of a lunar crater. We explore the moon's mountainous surface, its craters and "seas," its weird and colorful scenery. Our own earth, seen hanging in the sky, eclipses the sun. At length we turn our rocket ship about, and head for home.

★ **THE HAYDEN PLANETARIUM** presents in *July*, SUMMER STARS. (See page 12.)

In *August*, A TRIP TO THE MOON. The most exciting journey you'll ever take—by rocket ship zooming up through the earth's atmosphere and landing in a crater on the moon. Here you will see exactly what you would if you *could* travel to the moon—stars shining in a black noon sky, an entire absence of weather, the sun eclipsed by the earth. Come along—it's fun!

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays) ..... 3 and 8:30 p.m.
Sundays and Holidays ..... 3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Manager*, Frank S. McGary; *Public Relations*, John F. Landis; *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Associate Curator*, Marian Lockwood; *Assistant Curator*, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.